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Art. I.—*On Certain Meteorological Coincidences;* by J. H. Alexander, Esq.

That the phases of the Moon exercise no appreciable influence upon the weather, either as cause or concomitant, as agency or sign, is a dogma accepted and professed by most geometers and meteorologists, and, indeed, by savans generally; while the bulk of the unscientific portion of the community, and those whose pursuits are carried on chiefly in the open air, such as sailors, surveyors, agriculturalists, etc., are convinced that they trace a connection between the state of the Moon and state of the atmosphere, as real and hardly less constant and uniform than if it were predicted for them in a systematic theory.

I do not purpose to discuss the accuracy of these opposite views here; for which, there would be required a greater collection of observed material, and extending through longer periods than, I believe, the science of meteorology has yet been enriched with, and also individual faculties of learning, acuteness, and patience, in an excellent and rare degree.

But I may remark in passing that, with most persons, the scientific denial above mentioned is probably limited, in fact as in terms, to the *appreciability* of the influence in question with our means of observing, not to the actuality or possibility of the influence itself. At least such would most likely be the position taken upon reflection. For it would be hard to deny that the pulses and tides of the atmosphere are less harmoniously linked in with planetary attractions, or less under the domain of the principle of universal gravitation, than the tides of the ocean or the

motions of bodies still more dense. And it would be difficult to discredit the anticipation that, one day, Meteorology is to become more a science of calculation than it is at present; and that, then, phenomena, which as yet appear arbitrary or insignificant, will be recognized as elements in great normal formulæ, each term of which will be continually becoming more distinct and better known, until, as far as finite faculties allow, we approach that divine geometry of which Plato dreamed, and which cannot but be prescient since it knows the structure and conditions of existence and relations of all things.

But, without ascending to such lofty generalities as these, it might perhaps be even claimed by the believers in prognostics, that certain observations have been already made and discussed by sceptical philosophers,* whose normal occurrence may be affirmed with a high degree of probability; and which, although incapable as yet of being derived from, or bound in with, a sound theory, seem fully to deserve the character of *coincidences*. It is by such a term, not more modest than appropriate, that I prefer to designate the accordances that I have observed, and which this paper is intended to indicate.

These observations and the conclusions from them are not of recent origin; although, in so far, they do not rest upon regularly recorded and tabulated results. Years ago, when the enjoyment of weekly half-holidays was dependent more or less upon the state of the weather, it was of interest to me to have some means of prognosticating that state; and I watched and treasured up all indications which might serve to that end, until I came at last to the conclusion warranted by frequent experience, that *the third day before the New-moon regulated the weather on each quarter-day* of that lunation, and also *characterized the general aspect of the whole period*. Thus, if the New-moon happened on the 26th May, 1824, the term-day was the 24th May; the weather on which 24th May determined what was to be on the 26th May, and on the 3d, 11th and 19th June, the quarter-days, respectively, of that lunation.

Lately, upon an accidental reference to these coincidences, in conversation with certain friends who had paid much attention to the subject, an interest was expressed to have this supposed rule tested by some past systematic observations. Accordingly, I availed of my first leisure to resort to the daily meteorological observations at the Girard College, Philadelphia; and the accordance of these with the proposed rule and the consequent probability of that rule, are all that remain to be stated here.

These observations were made under the direction of Professor Bache, now the Superintendent of the Coast Survey of the United States; and have, both in the character of their Director and their own intrinsic evidence, all guarantee of their reliability. They ex-

* Arago: *Ann. du Bureau des Longitudes*, 1833.

tend altogether from June, 1840, to June, 1845, inclusive; comprehending 62 entire lunations or 248 epochs of possible coincidence.

These were not only *daily* observations, but for the greater part *hourly* observations even, of various particulars interesting to meterology. Of these, all that have been taken into account at present are those that relate to the aspect of the sky and character of the clouds; the density, moisture, temperature, etc., of the atmosphere, which bear only collaterally upon the point in question, may be as yet pretermitted.

A part of the time, the observations were not at such short intervals; and for four months in 1843, they were irregular. Also, during the whole series, observations were systematically omitted on Sundays: which day of the week, however, was of course sometimes the term-day and sometimes the quarter-day of a particular lunation. Owing to these circumstances, the series, for the purpose of this comparison, comes to be grouped as follows, viz:

(*a*) :	31	lunations;	in which all the days are given;
(*b*) :	12	do.	in which *one* quarter-day is missed;
(*c*) :	6	do.	do. *two* quarter-days are missed;
(*d*) :	1	do.	do. *three* do.
(*e*) :	1	do.	do. *four* do.
(*f*) :	7	do.	in which the term-day is missed;
(*g*) :	4	do.	in which observations were not regular.
	62	lunations;	covered by the series. Excluding the last three groups

of . . . 12 lunations, we have left

50 lunations, suitable for comparison and whose results are given here.

The method used in this comparison is much more stringent than in the observations upon which the supposed rule originally reposed. In these last, the range of the entire day (i. e., daylight) was allowed to verify the coincidences without respect to the precise *hour* of the day when the change of Moon occurred. And the same range (or looseness, if any one prefers to term it so) might even have been admitted now. But I preferred, for various reasons which need not be dwelt on, to observe the coincidences at the precise hours of change. The following extract from the note book in which the comparisons were copied from the printed Girard observations, and where, close together, come one of the accordant cases, and one of the most discordant, will exemplify, better than any description, the mode pursued.

Date.	Epoch.	Sky covered 10ths.	Clouds, etc.	Results.	
1843, May 27, 2h. M.	Term-day,	1·0	N., raining.		
29, 2h. M.	●	1·0	N., raining,		
June 5, 9h. M.	◔	1·0	Ci-cu., Cu.	accord't.	discord't.
12, 2h. A.	○	1·0	Cu-s.	# 1.	b 3
19, 3h. A.	◑	0·7	Cu.		
25, —	Term-day,	—	——	missed.	
July 25, 1h. M.	Term-day,	0·9	Hazy, Cu.		
27, 1h. M.	●	0·3	S. at hor.		
Aug. 2, 6h. A.	◔	1·0	Cu-s., Cu.	accord't.	
9, 11h. A.	○	0·3	Ci., Ci-cu., Ci-s., S.	# 4.	
18, 2h. M.	◑	—	Clear.		

Of these columns, the first, third and fourth are mere transcripts of the printed observations; with the hours of ☾'s change (morning or afternoon) supplied to the first column. The second and fourth belong to the comparison. It is to be observed, farther, that the supposed rule claimed no more than the distinction between *dry* and (as it is called) *falling* weather. Thus, the existence of nimbus or rain-cloud on any quarter day, *provided it did not rain*, might be taken as coinciding with the weather on a term-day which was *clear*. But I have not so taken it, in fact; and have reckoned the existence of nimbus as equivalent to rain, and noted it as accordant or discordant, as the case may be. However hardly this may strain the supposed rule, I have no doubt of the soundness of its being insisted on. On the other hand, the propriety of considering the weather on 18th Aug., 1843, as coincident with the weather on 25th July, 1843, for instance, will, I suppose, be equally admitted.

With this exposition of the principles and manner of the comparisons, of which throughout the extract above is an average sample, the aggregate results may now be stated.

Of the 31 lunations, then, contained in group (*a*),

16 agree throughout,
8 miss *once*,
4 miss *twice*,
2 miss *thrice*,
1 disagrees throughout.

31 in all.

If I were endeavoring to sustain the supposed rule, *coûte qui coûte*, as a matter of argument or opinion, instead of honestly seeking for information, the uniformity of bisection in this last series and the correspondence between the numbers and characters of the discordances, might be plausibly urged according to the received doctrine of probabilities as being of great weight.

Of the 12 lunations in group (*b*),

7 agree throughout,
5 miss once.

12 in all.

Of the 6 lunations in group (*c*),

5 agree throughout,
1 misses twice.

6 in all.

The single lunation, classed (*d*), which contains but one quarter-day, misses.

In lunations, then, there are under

(*a*)	16	accordant entirely;	15	discordant more or less;
(*b*)	7	do.	5	do.
(*c*)	5	do.	1	do.
(*d*)	0	do.	1	do.
	28	accordant throughout;	22	discordant more or less;

and the chances would be in every 100 times, 56 in favor of the supposed rule and 44 against it; or the final probability would be 1,27, etc.: 1, for the rule.

But this comparison by lunations is defective; inasmuch as it does not allow a distinction in the character and degree of the discordances. For this, as well as for the proportion of missing observations, it is better to make comparison by the actual *epochs* or quarter-days; designating separately the aggregate number of those which coincide with the term-days, of those which differ, and of those which have failed to be observed at all. Of course, every such epoch affords occasion for a coincidence; and in proportion to the number of actual coincidences out of a given number of such occasions will be the probability of the supposed rule.

Counting, then, by epochs, the aggregate are as under:

	Accordant.	Discordant.	Not Observed.
(*a*) . .	98	26	0
(*b*) . .	31	5	12
(*c*) . .	10	2	12
(*d*) . .	0	1	3
	139	34	27

If we leave the epochs *not observed* out of the question, the chances stand as rather more than 4 to 1 in favor of the rule; or its probability is a little more than $\frac{4}{5}$.

If we consider that among those unobserved epochs the chances of coincidence are even, then they will stand as 76·25 out of 100 in favor of the rule; or its probability is rather more than $\frac{3}{4}$. The lowest of these probabilities is greater than is sometimes taken as sufficient ground for human belief or human actions.

I may terminate this notice in the words of Carlini upon a similar occasion:* "Queste conclusioni non devono considerarsi ..... come quelle che converebbe dedurre dal paragone delle osservazioni continuate per un gran numero d'anni. Ciò nulla ostante, non ci è sembrato del tutto inutile il presentar quì i risultati delle poche osservazioni delle quali potevamo far uso; sperando che da essi possa trarsi qualche norma par istabilire un piano generale d'osservazioni meteorologiche che riesca il più opportuno allo studio de' fenomeni atmosferici."

* *Sulla Legge delle Variazoni Orarie del Barometro*, etc., Modena, 1848.

ART. II.—*On a Method for distinguishing between Biaxial and Uniaxial Crystals when in thin plates,—and the results of the examination of several supposed Uniaxial Micas;* by W. P. BLAKE. (Read before the American Association for the Advancement of Science, at Cincinnati, May, 1851.)

THE greater number of the "black micas" so-called, have a deep olive green or "bottle green" color, so deep as generally to be opaque when the thickness exceeds one-fourth of a millimetre.* The other colors most frequently observed are a dull brownish green, sometimes yellowish, and a fiery red. Of course their power of absorbing light varies greatly; thus, the mica from

Greenwood Furnace, olive green, is opaque in plates over		·500 mm. thick.
Sussex Co., N. J., (No. 115) bottle green,	" " " "	·222 "
St. Lawrence Co., (No. 116) brownish "	" " " "	·062 "
" (No. 113) olive green,	" " " "	·042 "

These thicknesses were taken with an instrument constructed by Soleil, for measuring the thickness of thin plates.† It is called a spherometer and was designed by M. Cauchoix.

In stating the color of specimens, I have given that color which they present when a plate sufficiently thin to be transparent is held near the eye, while the light from the clouds or window is allowed to pass through it. It is not therefore possible to examine plates of these micas in the ordinary way, even when the thickness is less than stated above; and of course when so very thin, the images formed around the pole or poles of the resultant axes, are much extended and it would generally be impossible to distinguish them or the dark bars which cross the center; and when they can be seen, they so nearly resemble the symmetrical image formed in uniaxial crystals that they cannot be distinguished from them.

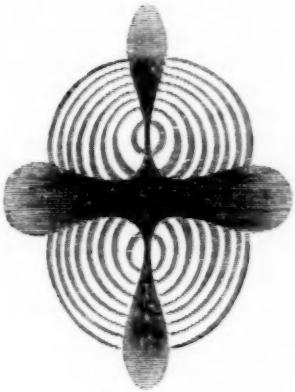
In order to enable me to give these dark micas a more complete and thorough examination, I have arranged, in addition to the combination of lenses and "Nichols Prism," which I described at the meeting of the American Association last August, a large convex lens, placed between the polarizing mirror of my instrument and the film of mineral to be examined; I also use, instead of the variable and uncertain light from the clouds, a broad gas flame, which I bring near to the mirror, so that its reflected image is condensed by the large convex lens upon the mica; with this arrangement I have been able to discern the *rings* and *cross* in plates of the dark micas much thicker than could be examined by any former arrangement. It now became interesting to examine some of the micas whose optical uniaxial character was equivocal, and for this purpose I adopted the following test.—

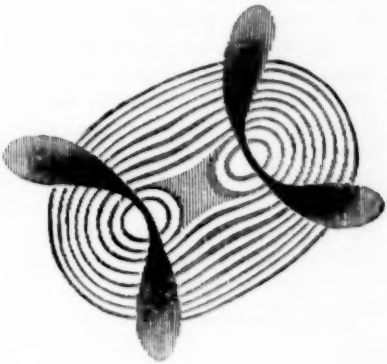
* Ordinary visiting cards are from ·3 to ·4 of 1 mm. thick.

† Described in E. Peclet's Traité de Physique, 4e ed. Paris, 1847, i, 5.

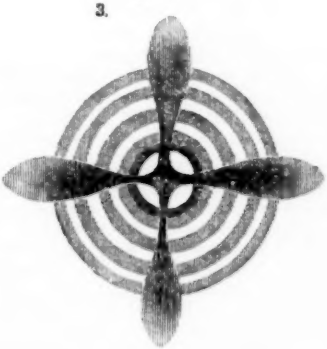
It is well known that where a plate of Iceland-spar, cut with faces perpendicular to the axis, is placed in a polariscope (the eye-piece being "crossed") and then rotated in its own plane, the symmetrical cross and rings do not suffer any change of form or position, if, however, a plate of a biaxial crystal—as nitre—be rotated in a similar manner, the dark bars which form the cross, as in fig. 1, will, when the plate has been rotated 45°, "open out," and take the form and position represented in fig. 2. These

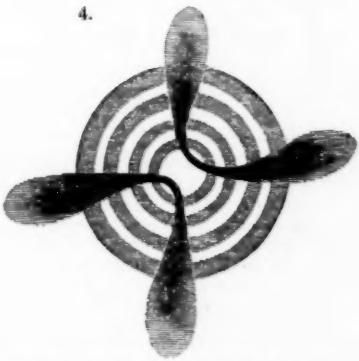
1. 2.





3. 4.





facts and figures, though familiar to the student of optics, I here repeat for the sake of the explanations which follow; and this is particularly important since observers of eminence have evidently mistaken the optical character of many of the so-called *uniaxial* or *hexagonal* micas. When the micas referred to are examined by my instrument I find the same evidence of a *biaxial* character. The thin plates, if the line joining the poles is parallel to the plane of primitive polarization, give to the eye symmetrical crosses and rings, as in fig. 3, that is, so *nearly symmetrical* that it is

hardly possible to distinguish any variation from symmetry, and such crosses might be taken as proof of a uniaxial character. But on rotating 45°, as in the case of the nitre crystal, we lose the symmetrical form of the cross, which opens out, as represented in fig. 4. This deportment of the cross may be observed when, owing to the depth of color, it is not possible clearly to discern the rings.

A method given by Müller* also depends upon this deportment of the dark bars; it consists in rotating the plate of mica when on the table of M. Noremberg's apparatus (the ray being extinguished by the eye-piece); if the mica be biaxial the light is alternately, for every 45° of rotation, transmitted or shut off, if *uniaxial*, no change is perceived. The image of the cross and rings by this method is so much extended and dimly defined, that the outlines cannot be traced by the eye, and a slight opening-out of the cross is not so readily noticed, even by a change in the intensity of the light, as when its image is contracted and sharpened in outline by the action of lenses.

In the following table are given the localities and color of several micas hitherto generally considered uniaxial, but which, on examination with my arrangement, have given evidence of being optically *biaxial*.

76.	Greenwood Furnace, Orange Co., N. Y.;	olive green; rhombic plates.†
77.	" " " " "	second specimen.
79.	" " " " "	third specimen.
86.	Easton, Pa.;	a white silvery mica.
88.	Topsham, Maine;	fine crimson red.
89.	Mount Vesuvius;	dark green.
101.	" " " "	Another specimen; clearly biaxial.
105.	" " " "	A thicker plate of specimen 101; clearly biaxial.
102.	" "	transparent, with delicate shade of green; banded with bands of a deep green, meeting at angles of 60°.

* Lehrbuch der Physik und Meteorologie, Braunschweig, 1844, p. 588.

† Greenwood furnace is in the town of Monroe, and this is the Monroe mica, analyzed by von Kobell (Kastn. Arch., xii, 29, and Dana's Min., 3d edit., 360) and pronounced by him on optical grounds to be uniaxial, it giving a symmetrical cross. It afforded the chemical formula $\dot{R}^3\ \ddot{S}i + (\dot{A}l, \dot{F}e)\ \ddot{S}i$, corresponding to the oxygen ratio for the protoxyds, peroxyds and silica 1 : 1 : 2. The exact ratio as worked out by Rammelsberg is 10·4 : 9·8 : 20·78, while the Vesuvian mica gave 10·1 : 10·0 : 20·65, and one from Bodenmais 10·25 : 10·96 : 21·23. The ratio is in fact the general ratio of the so-called "*hexagonal*" micas or Biotites. In the Greenwood furnace mica, we have evidence therefore that one at least of these Biotites is not hexagonal; and the same we believe true for some of the "hexagonal" Vesuvian micas. The importance of a revised crystallographic examination of these micas is hence obvious. The mica of Greenwood furnace is of a blackish green color, and occurs usually in very acute oblique prisms, often of very large size; angle of prism (M : M) 71° to 72°, it being oblique from an *acute* edge, and not from an *obtuse* edge as in ordinary biaxial mica. The angle between the base and a lateral plane (P : M) is 66°–67° and 103° to 114°, according to the writer's measurement. The replacement of the acute solid angle reduces the form to a rhombohedron with a basal cleavage plane, and thus it was taken by von Kobell. The faces of the crystals are so imperfect that the discrepancies obtained are usually one degree, on similar parts of the same crystal. Another Monroe mica (No. 81 above) is the only other mica which could possibly have been Kobell's, and that too is proved by Mr. Blake to be biaxial. J. D. D.

103. Mount Vesuvius; from same specimen as 102, but thicker; biaxial.
104. " " from same specimen, still thicker; gives good elliptical image.
142. " " beautiful green, like No. 101, is in small hexagonal crystals and associated with Idocrase.
111. Franklin Furnace, Sussex Co., N.J.; deep copper red; G. J. Brush to B. Silliman, Jr.
109. St. Jerome, Canada; coppery, reddish; angle, estimated 10°.
114. Moors Slide, Ottawa, Canada; dark bottle green; T. S. Hunt to B. Silliman, Jr.
116. St. Lawrence Co., N. Y.; dark brownish green; opaque, over ·062 mm. thick.
84. Hammond, St. Lawrence Co., N. Y.; rich smoky yellow; from Saml. W. Johnson.
68. " " dark brownish red; black by reflected light.
106. Gouverneur, N. Y.; (boulder) dark brown.
81. Monroe, Orange Co., N. Y.; dark green.
108. " " dark bottled-green; from S. R. Horton to B. Silliman, Jr.
107. Locality ——? Cambridge Cabinet; rich brown; in beautiful rhombic plates;
112. Locality ——? Cambridge Cabinet; deep green; like Greenwood Furnace mica.
63. Moriah, Essex Co., N. Y.; fiery red; Lederer Cabinet; angle measurable.
139. Warwick, Pa.; olive green (brownish); angle estimated over 10°; this much resembles the Vesuvius specimens, Nos. 102 and 103.

With the exception of the dark micas mentioned in the following table, I have not yet examined any that do not give evidence of being optically *bi*axial; and, it is probable, that these exceptions would give the modifications of the cross, &c., if their dark color did not make it impossible to observe them in plates sufficiently thick. But if biaxial, the angle for the mica of Sussex, New Jersey, No. 115, must be very small.

98. Locality ——? dark olive green; resembles No. 81.
83. Locality ——? Yale Coll. Cabinet; color intensely green.
115. Sussex Co., N. Y.; dark green; opaque when in plates over ·222 of 1 mm. thick.
113. Locality ——? N. Y. Lyc. Nat. Hist.; opaque in plates over ·042 mm. thick.
148. Middletown, Ct.; very dark green.
146. N. Y. Island; very dark olive-green; in granite veins traversing gneiss.
147. " " " " " "

To Prof. B. Silliman, Jr., I am indebted for the free use of his specimens for these investigations: the biaxial character of many of them was suspected by him, when he first examined them, as is mentioned in his communication in this Journal, vol. x, November, 1850.

In specimens of mica referable to the species Phlogopite, having the inclination of the resultant axes between 5° and 20°,—when the thickness is so much reduced that the systems of rings around poles are not distinctly separated, the angular inclination of the axes cannot be determined in the ordinary manner. Further observations upon this point I reserve for a future communication.

ART. III.—*On some of the Thermal Waters of Asia Minor;* by Dr. J. LAWRENCE SMITH, of New Orleans, Prof. Chem. in the University of Louisiana.

Part I.—*The Thermal Waters of Broosa.*

THERE are few countries where Thermal Waters are so numerous, and cover so extensive a surface as in Western Asia Minor; many of them still bear marks of the estimation in which they were held by the ancient Romans and Greeks for the purpose of supplying their baths.

Owing to the difficulty of obtaining proper vessels or corks at or near the springs, coupled with the risk of breakage by the necessary transportation on the backs of horses over rough and mountainous roads, travellers have been deterred from collecting these waters for the purpose of analysis. In my travels through certain parts of this country, I took along with me bottles and corks, and collected between twenty and thirty specimens of different localities, some of them in considerable quantity; and of that number fifteen or sixteen have arrived safely to my laboratory, where most of them have been already examined.

In my remarks upon them I will first allude to the thermal waters of Broosa or Prusia, which are the most important at the present day, and the most accessible from Constantinople. The spot itself is hallowed by many interesting historical associations. The city was founded by Hannibal during a friendly visit which this great Carthagenian general made to Prusias, the king of Bythinia, whose name was given to it. Like all other cities of so ancient date, it has gone through many changes, passing successively into the hands of the Greeks, Romans, and Turks. Since 1326 the Turks have continued masters of this part of Asia Minor, it having been conquered by Osman just prior to his death, for many years after which event it remained the capital of the Ottoman empire.

Broosa is readily reached from Constantinople by a steamer that goes from this latter place to Modania, on the gulf of the same name, about seventy miles from Constantinople. From Modania a ride of about twenty miles on horseback brings you to Broosa, at the foot of the Bythinian Olympus. The warm baths of this place have been celebrated from the earliest epochs, and the visit of Constantine with his wife in 797, is recorded in history as having resulted favorably in restoring the latter to health. And at a still later period Sultan Soleman the Great visited these baths on account of an attack of gout, and to commemorate his cure he had a large dome constructed over the source to which he attributed the beneficial effects derived by him; the dome still stands.

As it is not my object to enter here into the details of baths well known to all travellers in this part of Asia Minor, I shall at once proceed to the description of the sources. The sources of thermal waters near Broosa are seven in number, all situated in a little valley which separates *Mount Olympus* from *Mount Katairli*, and they are comprised within the distance of a mile and a half. In the immediate neighborhood of some of these sources, and sometimes in direct proximity, are sources of cool and delightful water that serve to regulate the temperature of the water used in the baths, of which there are as many as twenty private and public. These sources furnish waters of two description, the sulphurous and the non-sulphurous, and I shall commence with a description of the former.

THERMAL SULPHUR WATERS.

There are two sources of this class of water near Broosa, or rather two places near to each other where it flows out of the mountain, for my examination goes to prove that they are the same water. Their names are *Kukurtlu* and *Bademli-Baghtsche.*

Kukurtlu Source.

The name of the source signifies sulphur. It flows rapidly from the side of the mountain near to its base, through a bed of calcareous tufa, furnishing upwards of twenty gallons a minute, which, along with the water from a cold spring near by, is made to flow through the baths. There is a very sensible odor of sulphuretted hydrogen proceeding from the water of this source, more especially as it issues forth from the mountain, for there is a large amount of gas bubbling through the small reservoir into which the water rises, accompanied with a larger amount of vapor. As the water flows it leaves an incrustation of carbonate of lime, more or less colored with some organic matter. This source is held in particular veneration by the Greeks of the country, who usually assemble here twice a year to commemorate the martyrdom of St. Patrice, which was ordered by the Pro-consul of Broosa, and executed by his being thrown into this almost boiling spring.

The country is *geologically* made up of the older rocks, as granite, gneiss, limestone, &c., a silicious variety of the latter overlying the other two; in some parts, however, the limestone is remarkably pure, and has doubtless furnished to these waters that carbonate of lime so extensively deposited at the base of this part of the mountain in the form of tufa, which, for a mile or two of extent, rises several hundred feet above the plain at the foot of the mountain.

Physical Properties.—The water as taken from the source is perfectly clear and transparent, and remains so when kept in well corked bottles, but otherwise a yellow deposit is soon formed which

is probably crenate of lime. A slight odor of sulphuretted hydrogen, not perceptible when the water is cold. The taste of the water when cold is in no way peculiar, and it is very pleasant to drink. Specific gravity 1·00118. Temperature, (atmosphere at 66° Fah.,) 182° Fah., which varies but a few degrees with the seasons.

Chemical Composition.—The *gas* which escapes from the source was collected in inverted bottles, well corked and sealed, and in one thousand parts was found to contain—

Carbonic acid,	886
Nitrogen,	99
Oxygen	11
Sulphuretted hydrogen,	4

Solid contents in one litre of the water, 970 grammes. The water is alkaline, and, when concentrated to one third its bulk, gives a very sensible alkaline reaction with reddened litmus paper. It is found to contain the following ingredients in one litre:

	Grammes.		Grammes.
Carbonic acid, free,*	·3420	Lime,	·1415
Carbonic acid, fixed,	·1820	Magnesia,	·0142
Hydro-sulphuric acid,	·0012	Alumina,	·0012
Sulphuric acid,	·2140	Silica,	·1100
Chlorine,	.0103	Iron,	trace
Soda,	·2600	Organic matter (crenic acid),	·0350
Potash,	·0110		

These acids and bases may be represented as combining in the following manner:

Bi-carbonate of soda,	.4100	Sulphate of alumina,	·0043
Bi-carbonate of lime,	·1830	Chlorid of sodium,	·0170
Bi-carbonate of magnesia,	·0460	Hydro-sulphate of soda,	·0033
Sulphate of soda,	·1950	Carbonate of iron,	trace
Sulphate of potash,	·0202	Silica,	·1100
Sulphate of lime,	·1710	Organic matter,	·0342

The incrustation from this spring was next examined. One gramme of a beautiful crystalline portion was analyzed and found to contain—

Carbonate of lime,	·970	Silica,	003
Carbonate of magnesia,	·016	Organic matter,	trace
Sulphate of lime,	·008	Fluorid of calcium,	trace
Peroxyd of iron,	·011		

There are some portions of the incrustation richer in organic matter than this, but then the mixture is sensible to the eye, and does not represent the pure crystalline deposit of the spring.

* What is here meant, is, such of the carbonic acid as can be expelled in boiling the water.

The *Kukurtlu* source supplies two baths with water, one called the *Buyuk Kukurtlu* and the other the *Kutschuk Kukurtlu.*

The other source of sulphur thermal water is called—

Bademli Baghtsche.

This source is about three hundred feet from the latter, and flows from three or four openings in the tufa. On my visit to it the entrance to the sources was closed up with masonry, and the door could not be opened by the Turks from some superstitious motive. I was, however, enabled to procure the water a few feet from the source as it flowed through an open gutter; gas is said to escape abundantly from the source, just as in the Kukurtlu source.

Physical Properties.—It is clear and transparent, remaining so in well corked bottles; exposed to the air it gradually becomes cloudy, and deposits a yellowish sediment. Has a slight odor of sulphuretted hydrogen when warm. Specific gravity 1·00116. Temperature, (atmosphere at 67°,) 184° Fah.

Chemical Composition.—Solid contents, ·978 grammes in one litre. The water when concentrated reacts strongly alkaline. In one litre there are the following ingredients in grammes:

Carbonic acid, free, .	·2920	Lime, . . .	·1378
Carbonic acid, fixed, .	·1875	Magnesia, . . .	·0160
Hydro-sulphuric acid, .	·0010	Alumina, . . .	·0005
Sulphuric acid, . .	·2160	Silica, . . .	·1100
Chlorine, . . .	·0112	Iron, ...	trace
Soda, ...	·2650	Organic matter (crenic acid?), . .	·0402
Potash, . . .	·0130		

The combination of the acids and bases may be represented in the following manner:

Bi-carbonate of soda, .	·4070	Sulphate of alumina, .	·0020
Bi-carbonate of lime, .	·1790	Chlorid of sodium, .	·0192
Bi-carbonate of magnesia,	·0520	Hydro-sulphate of soda,	·0019
Sulphate of soda, .	·2000	Carbonate of iron, .	trace
Sulphate of potash, .	·0225	Silica, . . .	·1100
Sulphate of lime, .	·1660	Organic matter, . .	·0402

Two baths are also supplied from this source, the one called *Yeni-Kaplidja* and the other *Kainardja.*

It will be seen that in physical properties and chemical composition, the water of this source is identical with that of Kukurtlu; at which fact I was at first somewhat surprised, as an approximate analysis made some years ago by Dr. Bernard led me to look for a difference in the composition of these waters; and it was not until my analysis was completed that I became convinced that the waters of the Kukurtlu and Bademli-Baghtsche sources were the same, making its way through different openings in the tufa. I would merely remark here, that the an-

alysis made by Dr. Bernard must have been quite crude, as among other things he gives to a litre of the Kukurtlu water ·332 grammes of sulphuretted hydrogen, water which, when cold, has no hepatic odor, and has hardly a sensible effect on lead water.

None of the other sources near Broosa evolve a trace of sulphuretted hydrogen, and contain less solid matter; they are all alkaline, and give an alkaline reaction when concentrated.

THERMAL ALKALINE WATERS.

Of the alkaline waters, I have examined three sources situated at some distance from each other.

The *Kara Mustapha* source is about two hundred yards from the *Kukurtlu*, and almost on the border of the plain of Broosa; it supplies a bath bearing the same name.

Physical Properties.—Clear when taken from the source and kept in well stopped bottles. As the opening in the mountain from which it escapes is bricked over, it was impossible for me to ascertain if there were an abundant escape of gas. Temperature, 127° Fah. Specific gravity 1·00094.

Chemical Composition.—Solid contents in one litre ·541 grammes, and the same quantity of the water contains—

Carbonic acid, free,	·104	Lime,	·115
Carbonic acid, fixed,	·150	Magnesia,	trace
Sulphuric acid,	·068	Iron,	trace
Chlorine,	·005	Silica,	·066
Soda,	·132	Organic matter,	not estimated.

The combinations of the acids and bases may be represented as follows, in grammes:

Bi-carbonate of soda,	·2600	Chlorid of sodium,	·0084
Bi-carbonate of lime,	·2380	Carbonate of iron,	trace
Sulphate of soda,	·0452	Silica,	·0660
Sulphate of lime,	·0670	Organic matter,	not estimated.
Carbonate of magnesia,	trace		

Incrustations of carbonate of lime are deposited from this source, but not so abundantly as from the two first mentioned.

Tschekirghe Source.

The Tschekirghe source is about a mile and a half from Broosa, and supplies four baths, those of *Boigusel*, *Vani*, *Tschekirghe*, and *Yeni-Han*.

Physical Properties.—Clear, and does not readily deposit a sediment; the incrustation much less than at the other sources. No gas escapes from it as it flows from its source. Temperature, (air at 72° Fah.,) 113° Fah. Specific gravity 1·00068.

Chemical Composition.—Solid contents in one litre ·550 grammes; the same amount of the water contains—

Carbonic acid, free,	·040	Lime,	·168
Carbonic acid, fixed,	·094	Magnesia,	trace
Sulphuric acid,	·152	Iron,	trace
Chlorine,	trace	Silica,	·040
Soda,	·039	Organic matter,	not estimated.

Combined as—

Bi-carbonate of lime,	·2336	Sulphate of lime,	·2190
Carbonate of soda,	·0480	Chlorid of sodium,	trace
Carbonate of magnesia, Carbonate of iron,	traces	Silica,	·040
Sulphate of soda,	·0250	Organic matter,	not estimated.

The last source that I shall allude to is a very small one near to the *Kukurtlu*, and not connected with any bath, it is, however, used by the natives for the treatment of diseased eyes.

Gueuzayasma Source.

The Gueuzayasma source rises slowly in an excavation in the side of a rock, no gas whatsoever escaping from its surface; an incrustation is formed from it, that is in some places covered with a thin green coat resembling some of the salt of nickel or copper, it is, however, entirely of a vegetable character, and exhibits under the microscope a beautiful lace structure.

Physical Properties.—Clear and transparent; Temperature, 113° Fah. Specific gravity, 1·00122.

Chemical Composition.—Solid contents in one litre, ·901 grammes. One litre of the water contains—

Carbonic acid, free,	·220	Lime,	·175
Carbonic acid, fixed,	·150	Magnesia,	trace
Sulphuric acid,	·215	Iron and alumina,	trace
Soda,	·151	Silica,	·114
Potash,	·006	Organic matter,	not estimated.

Combined as follows:

Bi-carbonate of soda,	·2405	Sulphate of lime,	.2370
Bi-carbonate of lime,	·2249	Sulphate of alumina,	trace
Bi-carbonate of magnesia,	strong trace	Carbonate of iron,	trace
		Silica,	·1140
Sulphate of soda,	·1160	Organic matter,	not estimated.
Sulphate of potash,	·0110		

The incrustation of the spring contains 97 per cent. of carbonate of lime, the remainder is composed of carbonates of iron and magnesia and the sulphate of lime without a trace of fluorine.

These various springs it will be seen supply nine public baths, which vary in their size and magnificence, that of *Yeni-Kaplidja* being the largest and most beautiful; they are constructed on the usual plan of the Eastern baths, and consist of three parts:

First, a large hall, with an elevated platform all around two feet high, and sometimes galleries attached. It is on the platform that one disrobes himself prior to entering the bath, and it is also here that the bather reposes on a couch in retiring from the bath. This apartment is frequently ornamented with considerable luxury; it is well lighted, and there is sometimes in the middle a fountain, the falling of whose waters in the basin produces a freshness, and at the same time invites to slumber. This apartment is called by the Turks *Djamekian* (Vestiarium).

The next division in the bath is the *Soouklouk*, where one begins to experience the temperature of the inner bath, and where he reclines on a marble slab, and is either shampooed or places himself in the hands of the barber to be shaved, cupped or bled.

The third division is the *Hammam*, or bath properly speaking, where there is an atmosphere of 105° to 110° Fah., filled with the vapor of water arising from the heated marble floor. Here there are various recesses with small marble basins in which streams of hot and cold waters are allowed to flow; and once seated by one of them, an attendant of the bath takes possession of you, and puts you through a series of operations that can be better felt than described. The baths at Broosa have usually in the *Hammam* a large basin of hot water, into which the bathers can plunge, the one in the *Yeni-Kaplidja* is about five feet deep by thirty in diameter.

There is in some of these baths a small room called the *Boghoulouk* (Sudatorium), where the temperature is from 120° to 130° Fah. Once through the various operations of the bath one returns to the first room, reclines on a bed and indulges for a half hour or more in the Eastern luxuries of smoking and drinking coffee or sherbet.

This is a hasty sketch of the operations that the bather usually undergoes at these baths; but as numbers of invalids visit them, arrangements are made by which they can bathe in whatsoever way they may think best or the physician prescribe, for there are private apartments attached.

These thermal waters are in great repute in Turkey, and their effects are said to be most marked on chronic irritation of the abdominal organs; chronic rheumatism; gouts; chronic irritation of the mucus membrane of the intestines; diseases of the bladder, of the skin, and of the eyes, &c. These waters are also recommended to be taken internally when cold.

In the calcareous incrustation of three of these springs that were examined, I found the remains of two or three varieties of silicious infusoria after the lime had been dissolved out by an acid.

Some few remarks that I have to make with reference to the chemical analysis of these waters will be deferred until the publication of the second part of this paper.

New Orleans, March 14th, 1851.

ART. IV.—*Uses of the Stillingia sebifera or Tallow Tree, with a notice of the Pe-la, an Insect-wax of China:** By J. D. MACGOWAN, M.D.

THE botanical characters of this member of the Euphorbiacæ are too well known to require description; but hitherto no accurate account has been published of its varied uses, and although it has become a common tree in some parts of India and America, its value is appreciated only in China, where alone its products are properly elaborated. In the American Encyclopedia it is stated that this tree is almost naturalized in the maritime parts of South Carolina, and that its capsules and seeds are crushed together and boiled, the fatty matter being skimmed as it rises, hardening when cool.

Dr. Roxburgh in his excellent *Flora Indica*, says: "It is now very common about Calcutta, where in the course of a few years, it has become one of the most common trees. It is in flower and fruit most parts of the year. In Bengal, it is considered only an ornamental tree; the sebaceous produce of its seeds is not sufficient in quantity, nor its qualities so valuable, as to render it an object worthy of cultivation. It is only in very cold weather that this substance becomes firm; at all other times it is in a thick brownish fluid state, and soon becomes rancid: such is my opinion of the famous vegetable tallow of China."

Dr. Roxburgh was evidently misled in his experiments by pursuing a course similar to that which is described in the Encyclopedia Americana, (and in many other works,) or he would have formed a very different opinion of this curious material.

Analytical chemistry shows animal tallow to consist of two proximate principles—*stearine* and *elaine*. Now what renders the fruit of this tree peculiarly interesting is the fact that both these principles exist in it separately, in nearly a pure state. By the above named process, stearine and elaine are obtained in a *mixed* state, and consequently presents the appearance described by Dr. Roxburgh.

Nor is the tree prized merely for the stearine and elaine it yields, though these products constitute its chief value; its leaves are employed as a black dye; its wood being hard and durable may be easily used for printing blocks and various other articles, and finally, the refuse of the nut is employed as fuel and manure.

The *Stillingia sebifera* is chiefly cultivated in the provinces of Kiangsi, Kougnam, and Chehkiang. In one district, near Haugchan, the inhabitants defray all their taxes with its produce. It grows alike on low alluvial plains and on granite hills, on the

* Drawn up for the Agricultural and Horticultural Society of India.

rich mould at the margin of canals, and on the sandy sea beach. The sandy estuary of Haugchan yields little else; some of the trees at this place are known to be several hundred years old, and though prostrated, still send forth branches and bear fruit. Some are made to fall over rivulets, forming convenient bridges. They are seldom planted where any thing else can be conveniently cultivated—in detached places, in corners about houses, roads, canals, and fields. Grafting is performed at the close of March, or early in April, when the trees are about three inches in diameter, and also when they attain their growth. The Fragrant Herbal recommends for trial the practice of an old gardener, who instead of grafting, preferred breaking the small branches and twigs, taking care not to tear or wound the bark.

In mid-winter, when the nuts are ripe, they are cut off with their twigs, by a sharp cres-centric knife, attached to the extremity of a long pole, which is held in the hands, and pushed upwards against the twigs, removing at the same time such as are fruitless. The capsules are gently pounded in a mortar to loosen the seeds from their shells, from which they are separated by sifting. To facilitate the separation of the white sebaceous matter enveloping the seeds, they are strained in tubs, having convex, open wicket bottoms placed over cauldrons of boiling water. When thoroughly heated they are reduced to a mash in the mortar, and thence transferred to bamboo sieves, kept at an uniform temperature over hot ashes. A single operation does not suffice to deprive them of all their tallow, and the steaming and sifting is therefore repeated. The article thus procured becomes a solid mass on falling through the sieve, and to purify it, it is melted and formed into cakes for the press. These receive their form from bamboo hoops a foot in diameter and three inches deep, which are laid on the ground over a little straw. On being filled with the hot liquid the ends of the straw beneath are drawn up and spread over the top, and when of sufficient consistence are placed with their rings in the press. This apparatus, which is of the rudest description, and constructed of two large beams placed horizontally so as to form a trough, is capable of containing about fifty of the rings with their sebaceous cakes; at one end it is closed, and at the other adapted for receiving wedges, which are successively driven into it by ponderous sledge hammers, wielded by athletic men. The tallow oozes in a melted state into a receptacle below where it cools; it is again melted and poured into tubs, smeared with mud to prevent its adhering. It is now marketable, in masses about 80 pounds each—hard, brittle, white, opake, without taste, and without the odor of animal tallow; under high pressure it scarcely stains bibulous paper; melts at 104° Fahrenheit. It may be regarded as nearly pure stearine, the slight difference is doubtless owing to the admixture of oil expressed from the seed in the process just described. The seeds

yield about eight per cent. of this vegetable stearine, which sells for about five cents per pound.

The process for pressing the oil, which is carried on at the same time, remains to be noticed; it is contained in the *kernel* of the nut, the sebaceous matter which lies *between* the *shell* and *husk* having been separated in the manner described. The kernel and the husk covering it are ground between two stones, which are heated to prevent clogging from the sebaceous matter still adhering. The mass is then placed in a winnowing machine, precisely like those in common use in other countries. The chaff being separated exposes the white oleaginous kernels, which after being steamed are placed in a mill to be mashed. This machine is formed of a circular stone groove, twelve feet in diameter, three inches deep and about as many wide, into which a thick solid stone wheel, eight feet in diameter, tapering at the edge, is made to revolve perpendicularly by an ox harnessed to the outer end of its axle, the inner turning on a pivot in the centre of the machine. Under this ponderous weight the seeds are reduced to a mealy state; they are then steamed in the tubs, formed into cakes, and pressed by wedges in the manner above described, the process of mashing, steaming, and pressing being repeated with the kernels likewise. The kernels yield above thirty per cent. of oil, and it sells for a little more than three cents per pound. It is called *Tsing-yu*, and answers well for lamps, though inferior for this purpose to some other vegetable oils in use. It is also employed for various purposes in the arts, and has a place in the Chinese Pharmacopœia, because of its quality of changing grey hair black, and other imaginary virtues. The husk which envelops the kernel, and the shell which encloses them with their sebaceous covering, are used to feed the furnaces, scarcely any other fuel being needed for this purpose. The residuary tallow cakes are also employed for fuel, as a small quantity of it remains ignited a whole day. It is in great demand for chafing dishes in the cold weather. And finally, the cakes which remain after the oil has been pressed out are much valued as a manure, particularly for tobacco fields, the soil of which is rapidly impoverished by the Virginia weed. Artificial illumination is generally procured in China by vegetable oils, but candles are also employed by those who can afford it, and for lanterns. In religious ceremonies no other material is used. As no one ventures out after dark without a lantern, and as the gods cannot be acceptably worshipped without candles, the quantity consumed is very great. With an unimportant exception, the candles are also made of what I beg to designate as *vegetable stearine*. When the candles, which are made by dipping, are of the required diameter, they receive a final dip into a mixture of the same material and *insect-wax*, by which their consistency is preserved in the hottest weather. They are generally colored red, which is done by throwing a minute quan-

tity of Alkanet root (*Anchusa tinctoria*), brought from Shangtung, into the mixture, which forms the coating of the candle; Verdigris is sometimes employed to dye them green. The wicks are made of rush, coiled round a stem of coarse grass, the lower part of which is slit to receive the *pin* of the candlestick, which is more economical than if put into a socket. Tested in the mode recommended by Count Rumford, these candles compare favorably with those made from spermaceti, but not when the clumsy wick of the Chinese is used. They cost about eight cents per pound.

Prior to the thirteenth century, beeswax was employed as a coating for candles; but about that period the white *insect-wax* was discovered, since which time that article has been wholly superseded by the more costly but incomparably superior product of this insect. It has been described by the Abbé Grassier, Sir George Staunton, and others; but these accounts differ so widely among themselves, as well as from that given by native authors, as to render further inquiry desirable.

From the description given by Grassier, entomologists have supposed the insect which yields the *Pe-la*, or white wax, to be a species of Coccus. Staunton on the contrary describes it as a species of Cicada (*Flata limbata*). As described by Chinese writers, however, it is evidently an *apterous* insect, hence the inference, either that there are two distinct species that produce white wax, or that the insect Staunton saw was falsely represented as the elaborator of this beautiful material. This like many other interesting questions in the natural history of this portion of the globe must remain unsolved, until restrictions on foreign intercourse are greatly relaxed, or wholly removed. In the mean time, native writers may be consulted with advantage; and from the chief of these the Pun-tsau and Kiunfangpú, two herbals of high authority, the subjoined account has been principally derived. The animal feeds on an evergreen shrub or tree, *Ligustrum incidum*, which is found throughout central China from the Pacific to Thibet, but the insect chiefly abounds in the province of Sy'Chuen. It is met with also in Yunnan, Hunan, and Hupeh. A small quantity of a superior description, is produced in Kinhwa Chehkiang province. Much attention is paid to the cultivation of this tree; extensive districts of country are covered with it, and it forms an important branch of agricultural industry. In planting, they are arranged like the mulberry in rows about twelve feet apart, and both seeds and cuttings are employed. If the former, they are soaked in water in which unhusked rice has been washed, and their shells pounded off; when propagated by cuttings, branches an inch in diameter are recommended as of the most suitable size. The ground is ploughed semi-annually, and kept perfectly free from weeds. In the third or fourth year they are stocked with the insect. After the wax or insect has been gath-

ered from the young trees, they are cut down, just below the lower branches, about four feet from the ground, and well manured. The branches which sprout the following season are trimmed, and made to grow in nearly a perpendicular direction. The process of cutting the trunk within a short distance of the ground is repeated every four or five years, and as a general rule, they are not stocked until the second year after this operation. Sometimes the husbandman finds a tree which the insects themselves have attained, but the usual practice is to stock them with the nests of the insect, which is effected in spring. These nests are about the size of a "fowl's head," and are removed by cutting off a portion of the branch to which they are attached, leaving an inch each side of the nest. The sticks, with the adhering nests, are soaked in unhusked rice-water for a quarter of an hour, when they may be separated. When the weather is damp or cool, they may be preserved in jars for a week; but if warm, they are to be tied to the branches of the trees, to be stocked without delay, being first folded between leaves. By some, the nests are probed out of their seat in the bark of the tree without removing the branches. At this period they are particularly exposed to the attacks of birds, and require watching. In a few days after being tied to the tree, the nests swell, and innumerable white insects, the size of "*nits*," emerge, and spread themselves on the branches of the tree; but soon with one accord they descend towards the ground, where, if they find any grass, they take up their quarters. To prevent this, the ground beneath is kept quite bare, care being taken also that their implacable enemies, the ants, have no access to the tree.

Finding no congenial resting place below, they reascend and fix themselves to the lower surface of the leaves, where they remain several days, whence they repair to the branches, perforating the bark to feed on the fluid within. From nits they attain the size and appearance of "*pediculus hominis*." Having compared it to this, the most familiar to them of all insects, our authors deem further description superfluous. Early in June they give to the trees the appearance of being covered with hoar frost, being *changed into wax*, soon after this they are scraped off, being previously sprinkled with water. If the gathering be deferred till August they adhere too firmly to be easily removed. Those which are suffered to remain to stock trees the ensuing season secrete a purplish envelop about the month of August, which at first is no larger than a grain of rice; but as incubation proceeds, it expands, and becomes as large as a fowl's head, which is in spring, when the nests are transferred to other trees, one or more to each, according to their size and vigor, in the manner already described.

On being scraped from the trees, the crude material is freed from its impurities, probably the integuments of the insect, by spreading

it on a strainer covering a cylindrical vessel which is placed in a cauldron of boiling water; the wax is received into the former vessel, and on congealing is ready for the market. The Pe-la or white wax in its chemical properties is analogous to purified beeswax, and also spermaceti, but differs from both, being in my opinion an article perfectly *sui generis*. It is purely white, transparent, shining, not unctuous to the touch, inodorous, insipid, crumbles into a dry inadhesive powder between the teeth, with a fibrous texture, resembling fibrous calc-spar; it melts at 100° Fah., is insoluble in water, dissolves in heated essential oils, and is scarcely affected by boiling alcohol, the acids, or alkalies.

The aid of analytical chemistry is needed for the proper elucidation of this most beautiful material. There can be no doubt it would prove altogether superior in the arts to purified beeswax. On extraordinary occasions the Chinese employ it for candles and tapers. It has been supposed to be identical with the white lac of Madras; but as the Indian article has been found useless in the manufacture of candles,* it cannot be the same; it far excels also the vegetable wax (Myrica cerifera) of the United States.

Is this substance a secretion? There are Chinese who regard it as such, some representing it to be the saliva and others the excrement of the insect. European writers take nearly the same view, but the best authorities expressly say that this opinion is incorrect, and that the animal is changed into wax. I am inclined to believe that the insect undergoes what may be styled a ceraceous degeneration, its whole body being permeated by the peculiar produce in the same manner as the Coccus cacti is by *carmine*.

Its cost at Ningpo varies from 22 to 33 cents per pound.

The annual produce of this humble creature in China cannot be far from 400,000 pounds, worth more than $100,000.

Ningpo, August, 1850.

ART. V.—*On the sudden disappearance of the Ice on Lake Champlain, at the breaking up of Winter;* by Rev. ZADOCK THOMPSON, of Burlington, Vermont.

THE vanishing of the ice on Lake Champlain in spring is at times so sudden, as to strike general observers with much surprise. But, for myself, although I have lived thirty years upon its shores, where I have had a full view of its broadest part, and where I have watched its closing in winter and its opening in spring, with no inconsiderable interest, I have not in that time witnessed anything, in relation to the phenomenon above mentioned, which has appeared to me either mysterious or very wonderful. In the last fifty years there have been a few cases (cer-

* Dr. Pearson's Philosophical Transactions, vol. xxi.

tainly not more than three or four), in which the lake has been entirely covered with ice on one day, and entirely clear of ice on the next. One case only of this kind has occurred within the period of my own observations, and that took place about twenty years since. The ice at that time, though of considerable thickness, had become exceedingly porous and rotten, and for some days had been considered unsafe; but, having been stiffened at its surface by a sharp frost in the night, some persons ventured upon it in the morning, and passed safely over the lake on foot, where the width is six or seven miles; but during the day a storm set in, with a very strong wind, and, on the following morning, the ice had entirely disappeared; there was none to be seen on the lake.

Now an occurrence of this kind is certainly calculated to excite wonder in the mind of the general observer, and make the sudden clearing of the lake a common topic of conversation; but it appears to me that all the mystery about the matter vanishes at once whenever the circumstances are carefully considered. These circumstances I have stated in general terms in Part I, p. 14 of my Nat. and Civil Hist. of Vermont, published in 1842. But experiments and observations made since that time require me to modify some of the statements there presented. It was then supposed that, when the ice commenced forming upon the surface of the lake, the great body of water below was at a temperature of about 39° or 40°. This, according to the researches of Count Rumford, would doubtless be true were the waters cooled down without agitation; but I find it is not true in fact, and from the observations I have made, I am now inclined to the opinion that, in consequence of their violent agitation by the cold winds which prevail in the early part of winter, the whole mass of waters is usually cooled down very nearly to the freezing point before any ice forms at the top, and that, after the waters are protected from the winds by a covering of ice, their temperature is gradually raised by the reception of heat from the earth beneath.

Since the publication of my history of Vermont I have made some experiments for the purpose of ascertaining the temperature of the water of the lake at various depths, after it had been for some time entirely covered with ice. In all these I have found the temperature some degrees above freezing, but not quite so much above as I had previously supposed. As an example, I copy the following record from my meteorological journal for 1844:

"March 27. Temperature of the water of the lake in contact with the ice, 32°; *six* feet below the surface, 32½°; *twelve* feet below, 34½°; and *twenty-five* feet below, being the whole depth of the lake at that place, 35½°." These observations were made nearly one-fourth of a mile from the shore, and after the lake had been covered with ice about eight weeks.

It has long been my intention to ascertain the temperature at the bottom of the deeper parts of our lake when covered with ice,

but I have not hitherto examined where the depth has exceeded 35 feet; I should have attempted it this spring but for the unexpected disappearance of the ice, the last of March.*

A few days after the disappearance of the ice this year, I found the temperature of the water to be 36½°, and, as the lake was at the time much agitated by the wind, this was, doubtless, very nearly the mean temperature of the whole mass of water.

There are three well attested facts connected with this subject, which, taken together, appear to me to afford a full and satisfactory explanation of the phenomenon.

1. The great body of ice is previously always reduced to the *honey-comb* structure, in which condition any considerable agitation of the water causes it to separate into minute divisions.

2. The temperature of the great mass of water is always several degrees above the freezing point, and in a condition to dissolve the minute divisions of ice with great facility when agitated in it.

3. The phenomenon is always attended by a very high wind, producing the agitation required.

In addition to theoretic objections to the opinion that the ice sinks when it disappears suddenly, we, who live on the shores of the lake, think we have ocular proof that it does *not* take place. We see the ice, while yet spreading over the whole surface of the lake, gradually wasting as the spring advances, and becoming less firm, till at length it is so far disintegrated that a stick may be easily thrust through it, while it is still from six to twelve inches thick. This disintegration is often carried so far, before the general icy covering is disturbed, that the ice has little more solidity or tenacity than loose snow saturated with water. In this state of things a strong wind soon produces rents in the ice, the waters, before pent up and quiet, are thrown into violent agitation, and we actually see the slightly cohering masses falling to pieces and dissolving at the surface of the lake; but we never see the ice sinking, nor can I learn that any evidence of this has ever been observed in masses lying at the bottom of the lake.

The objection to this hypothesis—"that so sudden and extensive a conversion of a solid into a fluid, as it supposes, would produce a sudden and violent frost through the neighboring country,"—would, undoubtedly, have weight were the caloric required

* Although the lake this year began to open, in some places, before the middle of March, it remained mostly covered with ice of considerable thickness and firmness till the 29th of that month, when, in the afternoon, a brisk wind sprang up from the south, which increased to a strong gale during the night, and continued to blow with great violence in the same direction during the 30th and up to noon on the 31st, when it changed to the west and blew a strong gale in that direction through the remainder of the day. Before evening on the 30th, the ice had all vanished from the broader parts of the lake, and on the 1st day of April, the lake and bays, so far as visible from this place, were entirely cleared of ice. This, considering the thickness and firmness of the ice at the time, is one of the most remarkable clearances of the lake we have witnessed for several years.

to liquefy the ice supposed to be derived wholly or principally from the atmosphere. But this I do not believe to be the fact. The process of liquefaction is aided, more or less, according to the temperature, by the warmth of the atmosphere, and, to the same extent, the air is cooled; but the great supply of caloric for the liquefaction of the ice is derived from the waters beneath. This absorption of heat from the waters below has no effect in diminishing the temperature of the air above. By it, the great mass of water may be cooled down a few degrees, still leaving the surface of the lake, in contact with the atmosphere, warmer by some degrees than the previous covering of ice. If we assume, for example, the average depth of Lake Champlain to be fifty feet, and the thickness of the ice to be eight inches, and the temperature of the water below to be 36°, immediately before the sudden disappearance of the ice, (and these do not, probably, differ very much from the usual conditions,) then, since the heat of fluidity in water is 140°, it is easy to calculate that the sudden liquefaction of the ice, by heat derived wholly from the water, would diminish the temperature of the whole mass of water less than two degrees, leaving the surface in contact with the atmosphere more than two degrees warmer than the ice.

There are some other phenomena connected with this lake, which I regard as interesting, but I defer touching upon them to another time.

Burlington, Vermont, April, 1851.

Art. VI.—*On Coral Reefs and Islands;* by James D. Dana.—Part II.

From the Report on Geology of the Exploring Expedition under Capt. Wilkes, U. S. N.

3. Coral Islands.

A. Forms and general features of Coral Islands.

A barrier reef, and a lagoon enclosed by it, are the prominent features of a coral island; yet there are a few of small size in which the lagoon is wanting. In the larger islands, the waters within look like the ocean, and are similarly roughened by the wind, though not to the same extent. Standing on the north shore of the Raraka lagoon, (in the Paumotus,) and looking southwest, nothing is descried but blue waters;—far in the distance, to the right or left, a few faint dots are distinguished; and as the eye sweeps around, these gradually enlarge into lines of palms and other verdure, which finally become distinct groves on nearing the observer. At Dean's Island, another of the Paumotus, and at many of the Carolines, the resemblance to the ocean is still more striking. The lagoon is in fact but a fragment of the ocean cut

off by more or less perfect walls of coral reef-rock ; and the reef is here and there surmounted by verdure, forming a series of islets.

In many of the smaller coral islands, the lagoon has lost its ocean character, and become a shallow lake, and the green islets of the margin have coalesced in some instances into a continuous line of foliage. Traces may perhaps be still detected of the passage or passages over which the sea once communicated with the internal waters, though mostly concealed by the trees and shrubbery which have spread around and completed the belt of verdure. The coral island is now in its most finished state : the lake rests quietly in its bed of palms, hardly ruffled by the storms that madden the surrounding ocean.

From the islands with small lagoons, there is every variety in gradation down to those in which there is no trace of a lagoon. These simple banks of coral are the smallest of coral islands.

These remarks, in connection with the general view given on a preceding page, will prepare the reader to appreciate the following descriptions of various coral islands, illustrating their forms, actual size, and condition.

A single group of islands, the Tarawan or Kingsmills, (see Plate,) affords good examples of the principal varieties. The irregularity of shape and size is at once apparent to the eye. In the southernmost, *Taputeouea*, the form is very narrow, the length being thirty-three miles, with the width of the southern portion scarcely exceeding six miles, and that of the northern more than one-half less. The emerged land is confined to one side, and consists of a series of islets upon the eastern line of coral reef. The western side is for the most part some feet under water, and there is hardly a proper lagoon. Sailing by the island, to windward, the patches of verdure thus strung together seem to rise out of a long white line of breakers, the sea surging violently against the unseen coral reef upon which they rest.

Namouti, the next island north, is about twenty miles long by eight broad. The rim of land, though in fewer islets, is similar to that of Taputeouea in being confind to the reef fronting northeast. The reef of the opposite side, though bare of vegetation, stands near low tide level, and the whole encloses a large lagoon.

Nanouki and *Apamama*, though smaller than Namouti, have the same general character. Nanouki is triangular in shape, and has an islet on the western point or cape, which is quite prominent. Apamama differs from either of the preceding in having two narrow ship entrances to the lagoon, one through the northwestern reef, and another through the southwestern.

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* The plate is a reduced copy of the chart of these islands, as surveyed by the Exploring Expedition.

Kuria is a remarkable double island, without a proper lagoon. It consists of two neighboring groves, each about a square mile in extent, on adjacent patches of reef.

Maiana is quite regularly quadrangular, with an uninterrupted range of land on two of the four sides, and an exposed reef constituting the other two.

Tarawa consists of two sides of a triangle. The western reef is wanting, and the sea and lagoon have unbroken communication. In place of it, there are two to ten fathoms water, and a bottom of coral sand. Small vessels may sail in almost anywhere on this side to a good anchorage, and there is a passage for ships of the largest size. The depth within is greater than on the bar, and these inner waters obviously correspond to the lagoon of other islands.

Apia has much resemblance to Apamama in its forest border and lagoon. Moreover, there is a ship-entrance through the southwestern reef.

Maraki is one of the prettiest coral islands of the Pacific. The line of vegetation is unbroken; and from the mast-head it lies like a garland thrown upon the waters. The unpracticed eye scarcely perceives, in such a view, the variation from a circular form, however great it may be. The grove is partially interrupted at one point, where there are indications of a former passage through the reef.

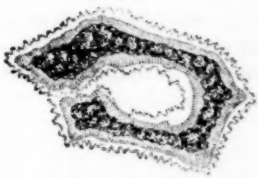
Tari-tari is a large triangular atoll. It is wooded almost continuously on the reef facing southeast, and has a few spots of verdure on the southwest, with three entrances to the extensive lagoon. The northern side is a naked reef throughout, scarcely apparent from a ship's deck, except by the long line of breakers. *Makin*, just north of Tari-tari, is a mere patch of coral reef without a lagoon.

We add a few more descriptions of Pacific islands, with figures reduced from the maps of the Expedition to a scale of four tenths of an inch to a mile.

1.

TAIARA.

2.



HENUAKE OF HONDEN.

Taiara and *Henuake*, (figs. 1 and 2,) are two small belts of foliage, somewhat similar to Maraki. Henuake possessed an additional charm in being tenanted only by birds; and they were so tame that we took them from the trees as if they had been their flowers.

Swain's and *Jarvis* Islands, (figs. 3 and 4,) are of still smaller size, and have no lagoon. The former is densely covered with foliage, while the surface of the latter is sandy. Swain's Island is a little depressed about the centre, a fact indicating that there was formerly a lagoon.

3.

SWAIN'S ISLAND.

4.

JARVIS ISLAND.

Fakaafo, or Bowditch, (fig. 5,) 200 miles north of Samoa, is the type of a large part of coral islands. The bank of reef has only here and there emerged from the waves and become verdant; in other portions the reef is of the usual height,—that is, near low tide level,—excepting a few spots elevated a little by the accumulation of sand.

5.

FAKAAFO.

The Paumotu Archipelago, the crowded cluster of coral islands just northeast of Tahiti, is a most instructive study for the reader; and a map of these islands by the Expedition, inserted in the Narrative of the Expedition, and also in the Hydrographical Atlas, will well repay close study. Sailing among these islands—over eighty in number, only four of which are over twelve feet high exclusive of the vegetation,—two or three are almost constantly in sight from the mast-head.

The small amount of habitable land on these reef-islands is one of their most peculiar features. Nearly the whole surface is water; and the land around the lagoon is but a narrow rim, the greater part of which is usually under water at high tide. This fact will be rendered more apparent from the following table, containing a statement of the sizes and areas of several islands, with the amount of habitable land. The measures are given in geographical miles.

	Length.	Greatest breadth.	Area in square miles.	Habitable parts in square miles.
Carlshoff, Paumotus,	27	13	200	10
Wolchonsky, "	15	3	40	3
Raraka, "	15	10	90	8
Manhii, "	14	6½	50	9
Nairsa or Deans, "	50	19	1000	16
Fakaafo, Union Group,	7½	4½	20	2½
Clarence, "	8½	5½	27	2
Taputeouea, Kingsmills,	33	6	60	6
Tarawa, "	20	10	130	8
Namouti, "	22	9	125	7
Tari-tari, "	18	11	110	4

The ten islands here enumerated have an aggregate area of 1952 square miles, while the amount of actual dry habitable land is but seventy-six miles, or less than one twenty-fourth. In the Caroline Archipelago the proportion of land is still smaller. Menchikoff atoll covers an area of 500 square miles, and includes hardly six square miles of wooded land. In the Marshall Islands the dry land is not over one-hundredth of the whole surface; while in the Pescadores the proportion of land to the whole area is about as 1 to 200.

The distribution of the land upon the reef is obvious from the sketches already given. It was long since remarked that the windward side was in general the highest. It is also apparent that there are not only great irregularities of form, but the reef may at times be wholly wanting or deeply submerged on one side.

In many islands there is a ship entrance, sometimes six or eight fathoms deep, through the reef to the lagoons, where good anchorage may be had; but the larger part have only shallow passages, or none at all. In the Paumotus, out of the twenty-eight visited by the Expedition, not one half were found to have navigable entrances. In the Carolines, where the islands are large and not so much wooded, entrances are of more common occurrence. About half of the Kingsmill Islands afford a good entrance and safe anchorage. Through these openings in the reefs, there is usually a rapid outward current, especially during the ebbing tide. At Depeyster Island, it was found to run at the rate of two and a half miles an hour. It was as rapid at Raraka, in the Paumotus, and as Capt. Wilkes remarks, it was difficult to pull a boat against it, into the lagoon.

Soundings about Coral Islands.—The water around coral islands deepens as rapidly and in much the same way as off the reefs about high islands. The atoll usually seems to stand as if stilted up in a fathomless sea. The soundings of the Expedition afford some interesting results.

Seven miles east of Clermont Tonnerre, the lead ran out to 1145 fathoms (6870 feet), without reaching bottom. Within three quarters of a mile of the southern point of this island, the lead, at another throw, after running out for a while, brought up an instant at 350 fathoms, and then dropped off again and descended to 600 fathoms without reaching bottom. On the lead, which appeared bruised, a small piece of white coral was found, and another of red; but no evidence of *living* zoophytes. On the east side of the island, three hundred feet from the reef, a bottom of coral sand was found in 90 fathoms; at one hundred and eighty feet, the same kind of bottom in 85 fathoms; at one hundred and thirty feet, a coral bottom in 7 fathoms;—and from this it decreased irregularly to the edge of the shore reef.

Off the southeast side of Ahii (another of the Paumotus), about a cable's length from the shore, the lead after descending 150 fathoms, struck a ledge of rock, and then fell off and finally brought up at a depth of 300 fathoms.

Two miles east of Serle's Island, no bottom was found at 600 fathoms.

A mile and a half south of the larger Disappointment Island, there was no bottom at 550 fathoms.

Near the eastern end of Metia, no bottom was found with a line of 150 fathoms; and a mile distant, no bottom was reached at 600 fathoms.* In general, for one to five hundred yards from the margin of the shore reef, the water slowly deepens, and then there is an abrupt descent, at an angle of 40 or 50 degrees. The results of earlier voyagers, among whom Beechey stands pre-eminent, correspond with this statement. At considerable depths, as would appear from the above facts, the sides of the coral structure may be vertical or even may overhang the bottom below.

There are examples also of less abrupt slopes. Northwest of the Hawaiian Group, Lisiansky, at the island bearing his name, found shallow water for a distance of six or seven miles; the water deepened to ten or eleven fathoms the first mile, fifteen the second, and at the last throw of the lead there were still but twenty-five fathoms.† Christmas Island affords on its western side another example of gradually deepening waters. Yet these shallow waters terminate finally in a rapid declivity of forty or fifty degrees. Off the prominent angles of an atoll, soundings generally continue much beyond the distance elsewhere, as was first observed by Beechey. At Washington Island, mostly abrupt in its shores, there is a bank, according to the surveys of the Expedition, extending from the east point to a distance of half a mile, and another on the west extending to a distance of nearly two

* Beechey, whose observations on soundings are the fullest hitherto published, states many facts of great interest. At Carysfort Island, he found the depth 60 yards from the surf line, 5 fathoms;—80 yards, 13 fathoms;—120 yards, 18 fathoms;—200 yards, 24 fathoms;—and immediately beyond, no bottom with 35 fathoms. At Henderson's Island, soundings continued out 250 yards, where the depth was 25 fathoms, and then terminated abruptly. Off Whitsunday, 500 feet out there was no bottom at 1500 feet.

Darwin states many facts bearing upon this subject, of which we may cite the following.—At Heawandoo Pholo (one of the Maldives) Lieutenant Powell found 50 or 60 fathoms close to the edge of the reef. One hundred fathoms from the mouth of the lagoon of Diego Garcia, Captain Moresby found no bottom with 150 fathoms. At Egmont Island, 50 fathoms from the reef, soundings were struck in 150 fathoms. At Cardoo Atoll, only 60 yards from the reef, no bottom was obtained with a line of 200 fathoms. Off Keeling Island, 2200 yards from the breakers, Captain Fitzroy found no bottom at 1200 fathoms. Mr. Darwin also states that at a depth between five and six hundred fathoms, the line was partly cut as if it had rubbed against a projecting ledge of rock; and deduces from the fact "the probable existence of submarine cliffs."

† Voyage round the world, in the years 1803–6, in the ship Neva, by N. Lisiansky, Captain in the Russian Navy, 4to, London: pp. 254–257.

miles. At Kuria, one of the Kingsmills, soundings continue for three miles from the north extremity, along a bank stretching off from this point to the north-northwest. Many other instances might be cited, but they are seldom as remarkable; yet nearly all islands, especially if the points are much prominent, afford similar facts. It has been said that the reef to leeward is generally less abrupt than that to windward, but no facts were obtained by the Expedition sufficiently definite or extensive to settle this question. It is probably true, yet the difference if any must be slight.

B. Structure of Coral Islands.

The descriptions of reefs and their islets apply with equal force to coral islands. By transferring here the statements respecting the former, we should have a nearly complete account of the latter. The same causes, with scarcely an exception, are at work:—the growing of coral-zoophytes, the action of the waves, oceanic currents, and the winds. This resemblance will be rendered more apparent by a review of their characters; the description will be found to be a simple recapitulation of a former paragraph.

The reef of the coral atoll, as it lies at the surface still uncovered with vegetation, is a platform of coral rock, usually two to four hundred yards wide, and situated so low as to be swept by the waves at high tide. The outer edge, directly exposed to the surf, is generally broken into channels and jagged indentations, along which the waters of the resurging wave drive with great force. Though in the midst of the breakers, the edge stands a few inches, and sometimes a foot, above other parts of the platform; the incrusting *Nullipores* cover it with varied tints, and afford protection from the abrading action of the waves. There are usually three to five fathoms water near the margin; and below, over the bottom which gradually deepens outward, beds of corals are growing profusely among lifeless patches of coral sand and fragments. Often the dead areas much exceed those flourishing with zoophytes, and not unfrequently the clusters are scattered like tufts of vegetation in a sandy plain. The growing corals extend up the sloping edge of the reef, nearly to low tide level. For ten to twenty yards from the margin, the reef is usually very cavernous or pierced with holes or sinuous recesses, a hiding-place for various crabs, or a retreat for the echini, asterias, the sea-anemones, and many a pretty mollusc; and over this portion, the gigantic Chama or Tridacna is generally found lying more than half buried in the solid rock, with barely room to gape a little its ponderous shell, and expose to the waters a gorgeously colored mantle. Farther in are occasional pools and basins, alive with all that lives in these strange coral seas.

The reef-rock, wherever broken, shows a detritus origin. Parts are of compact homogeneous texture, a solid white limestone, without a piece of coral distinguishable, and rarely an imbedded shell. But generally the rock is a breccia or conglomerate, made up of corals cemented into a compact mass, and the fragments of which it consists are sometimes many cubic feet in size.

SECTION OF A CORAL ISLAND REEF.

It is apparent that we are describing a second time an *outer* reef. Without dwelling farther upon its characters, we may pass to the features of the reef when raised above the waters and covered with vegetation.

Sections of coral islands and their lagoons have been given by Captain Beechey and Mr. Darwin. We add another, by way of illustration, although little may be presented that is novel after the excellent descriptions of these authors. Sketches of several of these islands, showing the general relation of the rim of land to the reef and the lagoon within, are given in the Plate of the Kingsmill Group. The following sketch represents a section of the rim of land from the sea on one side, (the left,) to the lagoon on the other. In the view, the part *m a*, represents the shallow sea bordering an island, and abruptly deepening one to six hundred feet from the line of breakers. In these shallow waters are the growing corals; yet, as before stated, a large part is barren sand or coral rock.

From *a* to *b* is the shore platform of reef-rock, nearly at low tide level, with the margin (*a*) slightly elevated, and much incrusted at the top with Nullipores. From the platform there is a rise by a steep beach (*b c*,) of six or eight feet, to the wooded part of the coral belt represented between *c* and *d*. From *d* to *e* there is a gently sloping beach bordering the lagoon. Beyond *e*, the waters of the lagoon at first deepen gradually, and then fall off more or less abruptly.

In the Paumotus, the shore platform, the steep beach, and the more gently sloping shore of the lagoon are almost constant characteristics.

The width of the whole rim of land, when the island gives no evidence of late elevation, varies from three hundred yards to one-third of a mile, excepting certain prominent points, more exposed to the united action of winds and waves and from opposite directions, which occasionally exceed half a mile.*

* Beechey states that the rim is generally three to four hundred yards in width, and never exceeds half a mile.—*Voyage*, Amer. ed., p. 160.

Shore platform and emerged land.—The shore platform is from one to three hundred feet in width, and has the general features of a half-submerged outer reef. Its peculiarities arise solely from the accumulations which have changed the reef into an island. Much of it is commonly bare at low tide, though there are places where it is always covered with a few inches or a foot of water; and the elevated edge, the only part exposed, often seems like an embankment preventing the water from running off. The tides, as they rise, cover it with water throughout, and bear over it coral fragments and sand, comminuted shells and other animal remains, to add them to the beach. The heavier seas transport larger fragments; and at the foot of the beach there is often a deposit of blocks of coral or coral rock, a cubic foot or so in size, which low tide commonly leaves standing in a few inches of water.†

Besides the deep channels cutting into the margin of the reef and giving it a broken outline, there are in some instances long fissures intersecting its surface. On Aratica, (Carlshoff,) and Ahii, (Peacock Island,) they extended along for a fourth to half a mile, generally running nearly parallel with the shore, and at top were from a fourth to half an inch wide. These fissures are not essential features of the reef, and will come up for consideration on a future page of this work.

The *beach* usually slopes at an angle of 35 to 45 degrees, and consists of coral pebbles or sand, with some worn shells, and occasionally the exuviæ of crabs and bones of fishes. Owing to its whiteness, and the contrast it affords to the massy verdure above, it is a remarkable feature in the distant view of these islands, and often seemed like an artificial wall or embankment running parallel with the shores. On Clermont Tonnerre, the first of these islands visited by us, the natives seen from shipboard, standing spear in hand along the top of the beach, were believed by some to be keeping patrol on the ramparts of a kind of fortification. This deception arose from the dazzling whiteness of the coral sand, in consequence of which, the slope of the beach was not distinguished in so distant a view.

The *emerged land* beyond the beach, in its earliest stage when barely raised above the tides, appears like a vast field of ruins. Angular masses of coral rock, varying in dimensions from one to a hundred cubic feet, lie piled together in the utmost confusion; and they are so blackened by exposure, or from incrusting lich-

† On moving these masses, which generally rest on their projecting angles and have an open space beneath, the waters at once become alive with fish, shrimps, and crabs, escaping from their disturbed shelter; and beneath, appear various Actinæ or living flowers, the spiny echini and sluggish biche-la-mar, while swarms of shells having a soldier crab for their tenant walk off with unusual life and stateliness. Moreover, delicate corallines, Ascidiæ and sponges tint with lively shades of red, green, and pink, the under surface of the block of coral which had formed the roof of the little grotto.

ens, as to resemble the clinkers of Mauna Loa; moreover, they ring like metal under the hammer. Such regions may be travelled over by leaping along from block to block, with the risk of falling into the many recesses among the huge masses. On breaking an edge from the black masses, the usual white color of coral is at once apparent. Some of the blocks, measuring five or six feet in each of their dimensions, were found to be portions of individual corals, while others have the usual conglomerate character of the reef-rock.

In the next stage, coral sand has found lodgment among the blocks; and though so scantily supplied as hardly to be detected without close attention, some seeds have taken root, and vines, purslane, and a few shrubs begin to grow, relieving the scene, by their green leaves, of much of its desolate aspect.

Both of these stages are illustrated on the greater part of coral islands.

In the last stage, the island stands six to ten feet out of water. The surface consists of coral sand, more or less discolored by vegetable or animal decomposition. There is but little depth of coral soil, although the land may appear buried in the richest foliage: and scattered among the trees, stand, still uncovered, many of the larger blocks of coral, with their usual rough angular features and blackened surface. The soil is seldom discolored beyond four or five inches, and but little of it to this depth; there is no proper vegetable mould, but a simple mixture of darker particles with the white grains of coral sand. It is often rather a coral gravel, and below a foot or two, it is usually cemented together into a more or less compact coral rock.

One singular feature of the shore platform, occasionally observed, remains to be mentioned. Huge masses of reef-rock are sometimes found upon it, some of which lie loose upon the reef, while others are firmly imbedded in it below, and so cemented to it as to appear to be actually a part of the platform rock. Sketches of some of these masses are here given.

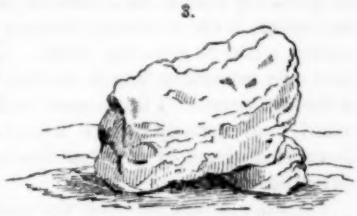
1.

2.

Figure 1 represents a mass on the island of Waterland, (one of the Paumotus,) six feet high, and about five in diameter; it was solid with the reef-rock below, as though a part of it, and about two feet above its base, it had been so nearly worn off by the waters as to have become irregularly top-shape. Figure 2 is

another mass, similarly attached to the reef at base, observed on Kawehe, (Vincennes Island.) It was six feet high above low water level, and seven feet in its longest diameter. Below, it had been worn like the one just described, though to a less extent. Another similar mass was eight feet high. Figure 3 represents a block six feet high and ten feet in its longest diameter, seen on Waterland; it was unattached below, and lay with one end raised on a smaller block. On Aratica, (Carlshoff,) others were observed. One loose mass like the last was eight feet high and fifteen feet in diameter, and contained at least a *thousand cubic feet.* Raraka also afforded examples of these attached and unattached blocks, some standing with their tops six feet above high-water mark.

3.



These masses are similar in character to many met with among the fields of blocks just described, and differ only in having been left on the platform instead of being transported over it. Some of them are near the margin of the reef, while others are quite at its inner limit. The third mass figured above was a solid conglomerate, consisting of large fragments of Astræas and Madrepores, and contained some imbedded shells, among which an Ostræa and a Cypræa were noticed. This is their usual character. The other two were parts of large individual corals, (Porites;) but there was evidence in the direction of the cells that they did not stand as they grew; on the contrary, they had been upthrown, and were afterwards cemented with the material of the rock beneath them, probably at the time this rock itself was consolidated. Below some of the loose masses like figure 3, (as on Aratica,) the platform was at times six inches higher than on either side of the mass, owing to the protection from wear given to the surface beneath it. These blocks are always extremely rough and uneven, like those of the emerging land beyond; and the angular features are partly owing in both cases to solution from rains or from the sea-water that may be dashed over them.

It should be distinctly understood that these masses here described were found isolated, and only at considerable intervals. In no instance were they observed clustered. The loose blocks and those cemented below had the same general character, and must have been placed where they were by the same cause, though it may have been at different periods.

The shore of the lagoon is generally low and gently inclined, yet in the larger islands, in which the waters of the lagoon are much disturbed by the winds, there is usually a beach resembling that on the seaward side, though of less extent. A plat-

form of reef-rock at the same elevation as the shore platform sometimes extends out into the lagoon; but it is more common to find it a little submerged and covered for the most part with growing corals: and in either case, the bank terminates outward in an abrupt descent of a few yards or fathoms, to a lower area of growing corals, or a bottom of sand. Still more commonly, we meet with a sandy bottom gradually deepening from the shores without growing coral. These three varieties of condition are generally found in the same lagoon, characterizing its different parts. The lower area of growing corals slopes outward, and usually ceases where the depth is 10 to 12 fathoms; from this there is another descent to the depth which prevails over the lagoon.

On some small lagoons the shore is a thick plastic mud, either white or like clay, and forms a low flat which is very gently sloping. On Henuake, these mud deposits are quite extensive, and of a white color. At Enderby's Island, another having a shallow lagoon, the mud was so deep and thick that there was some difficulty in reaching the waters of the lagoon; the foot sunk in 8 or 10 inches and was not extricated without some difficulty. The color at this island was a dirty brownish clay. This mud is nothing but comminuted coral, so fine as to be almost impalpable.

The *lagoons* of the smaller islands are usually very shallow; and in some, merely a dry bed remains, indicating the former existence of water. Instances of the latter kind are met with only in islands less than three miles in diameter; and those with shallow lagoons are seldom much larger. These shallow waters, when direct communication with the sea is cut off, become, in some instances, very salt by evaporation, and contain no growing coral, with few signs of life of any kind: and in other cases, they are made too fresh for marine life, through the rains. At Enderby's Island the water was not only extremely saline, but the shores of the lagoon were in some places incrusted with salt. But when there is an open channel, or the tides gain access over a bare reef, corals continue to grow, and a considerable portion of the lagoon may be obstructed by them. At Henuake, the sea is shut out except at high water, and there were consequently but few species of corals, and those of small size. At Ahii (Peacock's Island) there was a small entrance to the lagoon, and though comparatively shallow, corals were growing over a large part of it.

In the larger islands, the lagoons contain but small reefs compared with their whole extent; the greater part is an open sea, with deep waters and a sandy bottom. There are instances, as at the southern Maldives, of a depth of 50 and 60 fathoms. Twenty to thirty-five fathoms is the usual depth in the Paumo-

tus. This was the result of Captain Beechey's investigations; and those of the Expedition, though few, correspond. It is however probable that deeper soundings would be found in the large island of Nairsa (Dean's). In the Tarawan Group, southeast of the Carolines, the depth, where examined by the Expedition, varied from 2 to 35 fathoms. Mr. Darwin found the latter depth at Keeling's Island. Chamisso found 25 to 35 fathoms at the Marshall Islands.

The bottom of these large lagoons is very nearly uniform, varying but little except from the occasional abrupt shallowings produced by growing patches of reef. Soundings bring up sand, pebbles, shells, and coral mud; and the last mentioned material appears to be quite common, even in lagoons of considerable size. It has the same character as above described. The bluish clay-like mud of the harbor of Tongatabu may be classed with these deposits.* It appears, therefore, that the finer coral material of the shores prevails throughout the depths of the lagoon. The growing reefs within the lagoons, are in the condition of the *inner* reefs about high islands. The corals grow but little disturbed by the waves, and the reef-rock often contains them in the position of growth. At Taputeouea (Kingsmills or Tarawan Group), reefs very similar to those of the Feejees occur; they present the same large Astræas 10 to 12 feet in diameter, which once were growing where they stand but are now a part of the solid lifeless rock.

Beach formations of coral sandrock are common on the coral islands, and they present the same features in every respect, as those described. They were observed among the Paumotus, on Rarakā, Honden, Kawehe, and other islands. The stratified character is always distinct and the layers slope toward the water at the usual small angle, amounting to 5–7 degrees bordering the lagoon, and 7–8 degrees on the seashore side of the land. They often occupy a breadth of 30 to 50 yards, appearing like a series of outcrops; yet not unfrequently they are mostly concealed by the sands of the beach,† and it is probable that it generally underlies the loose surface material of the land. The rock is a fine or coarse sandrock, or a coral pudding-stone, and consists of beach materials. Occasionally it is quite compact, and resembles common limestone, excepting in its whiter color; but generally its sand origin is very apparent.

The *drift sandrock* was not met with by the writer on any coral islands visited, and probably for the reason that opportuni-

* Darwin describes this mud as occurring at the Maldives, and at Keeling Island, (op. cit. p. 26;) Kotzebue mentions it as common at the Marshall Atolls, and Lieutenant Nelson observed it at the Bermudas.

† On the northern atolls of the Maldives, the beach sandrock is said to be quarried out in square blocks and used for building.—*Journ. Geog. Soc.*, v, 400.

ties were not favorable for a thorough exploration. It has been stated that the more exposed points towards the trades, especially the northeast and southwest, are commonly a little higher than other parts; and it is altogether probable that some of the sand heaps, there formed, will prove on examination to afford examples of this variety of coral-rock. Such situations are exactly identical with those on Oahu, where they occur on so remarkable a scale. Mr. R. H. Schomburgh states that on the island of Anegada in the West Indies, the drift banks on the windward shores are forty feet in height.*

Although in these descriptions of atolls, we have dwelt on some points more at length than when describing barrier reefs, still it will be observed that the former have no essential peculiarities of structure apart from such as necessarily arise from the absence of high rocky lands. The encircling atoll-reef, corresponds with the outer reefs that enclose high islands; and the green islets with the beach formations, in the two cases, originate in the same manner.

The lagoons, moreover, are similar in character and position to the inner channels within barrier reefs; they receive only coral material from the action of degrading agents, because no other source of detritus but the reefs is at hand. The accumulations going on within them are, therefore, wholly of coral. The reefs within the lagoons, correspond very exactly in mode of growth and other characters to the *inner* reefs under the lee of a barrier. The corals grow but little disturbed by the waves, and the reef-rock thus formed, often contains them in their natural positions.

The preceding descriptions, represent the general character of atolls, but are more especially drawn from the Paumotus. There are some peculiarities in other seas, to which we may briefly allude.

Among the scattered coral islands north of the Samoan Group, the shore platform is seldom as extensive as at the Paumotus. It rarely exceeds fifty yards in width, and is cut up by passages often reaching almost to the beach. It was not unusual for our boats to obtain a landing by watching for a favorable opportunity at the entrance of one of these channels to mount a wave and ride in on its top. In some places the platform is broken into islets. Enderby's Island is one of the number to which this description applies: the beach is eleven or twelve feet high. For the first eight feet, it slopes very regularly at an angle of 30 to 35 degrees, and consists of sand, coarse pebbles, or rounded stones of coral, with some shells; and there is the usual beach conglomerate near the water's edge. After this first slope, it is hori-

* Journal of the Royal Geographical Society, ii, 152. Mr. Schomburgh describes the sandhills as 40 feet in height, and behind the first range, a second, and even a third.

zontal for eighty to two hundred feet, and then there is a gradual rise of three to four feet. Over this portion there are large slabs of the beach conglomerate, along with masses from the reef-rock, and some thick plates of a huge foliaceous Madrepora; and these slabs, many of which are six feet square, lie inclining quite regularly against one another, as if they had been taken up and laid there by hand. They incline in the same direction with the slope of the beach. The large Madrepora alluded to has the mode of growth of the Madrepora palmata; and probably the entire zoophyte extended over an area twelve or fifteen feet in diameter. The fragments are three to four inches thick, and thirty square feet in surface.

As a key to the explanation of the peculiarities here observed, it may be remarked that the tides in the Paumotus are two to three feet, and about Enderby's Island five to six feet in height.

Maldives.—Chagos Bank.—The Maldives have been often appealed to in illustration of coral structures. They are particularly described by Mr. Darwin, from information communicated to him by Captain Moresby, and from the charts of this officer and Lieutenant Powell.* The point of special interest in their structure is the occurrence of atolls or rings within the larger atolls. The islets of the lagoon, and those of the encircling reef, are in many instances annular reefs, each with its own little lake. Gems within gems are here clustered together.

The annular islets of the main encircling reef are oblong, and lie with the longest diameter, which is sometimes three miles long, in the line of the reef. Those of the lagoon are generally less than two miles across. The lagoons they contain vary from five fathoms or less to twelve fathoms in depth.

The Maldives are among the largest atoll-reefs known; and they are intersected by many large open channels; and Mr. Darwin observes, that the interior atolls occur only near these channels, where the sea has free access. We may view each large island in the archipelago as a sub-archipelago of itself. Although thus singular in their features, they illustrate no new principles with regard to reef-formations.†

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* Darwin on Coral Reefs, p. 32. See also Journal of the Royal Geographical Society, on the Geography of the Maldives, by J. J. Horsburgh, ii, p. 72; and by Captain W. F. W. Owen, ibid, p. 81; also vol. v, p. 398, on the Northern Atolls of the Maldives, by Captain Moresby.

† Mr. Darwin thus remarks, (Op. cit. pp. 33, 34,)—"I can in fact point out no essential difference between these little ring-formed reefs, (which, however, are larger, and contain deeper lagoons than many true atolls that stand in the open sea,) and the most perfectly characterized atolls, excepting that the ring-formed reefs are based on a shallow foundation instead of the floor of the open sea, and that instead of being scattered irregularly, they are grouped closely together."—"It appears from the charts on a large scale, that the ring-like structure is contingent on the marginal channels or branches being wide, and consequently on the whole interior of the atoll being freely exposed to the waters of the open sea. When the

The *Chagos Bank* lies about ten degrees south of the Maldives, and is ninety miles long and seventy broad. The rim is mostly submerged from five to ten fathoms.

Mr. Darwin confirms the opinion of Captain Moresby, that this bank has the character of a lagoon reef, resembling one of the Maldives; and he states on the evidence of extensive soundings, that, if raised to the surface, it would actually become a coral island, with a lagoon forty fathoms deep. In the words of Capt. Moresby, it is in truth nothing more than a half-drowned atoll.*

Metia and other elevated Coral Islands.—In the Chagos Group we have an example of a *sunken* coral atoll. Metia affords an instance of one that has been *elevated* by some force; and several such are met with in the Pacific. Metia, or Aurora Island, is one of the western Paumotus. It is a small island about four miles by two and a half in width, and two hundred and fifty feet in height; and it consists throughout of coral limestone. As we approached it from the northeast, its high vertical cliffs were supposed to be basaltic, and had much resemblance to the Palisades of the Hudson.† This appearance of a vertical structure was afterwards traced to vertical furrowings by the waters dripping down its front, and the consequent formation of stalagmitic incrustations. Deep caverns were also seen.

The cliff, though vertical in some parts, is roughly sloping in others, and on the west side, the surface of the island gradually declines to the sea.

The rock was found to be a white and solid limestone, seldom presenting any traces of its coral origin. In some few layers there were disseminated corals, looking like imbedded fossils, along with beautiful casts of shells; but for the most part it was as compact as any secondary marble, and as uniform in texture. Occasionally there were disseminated spots of crystallized calc-spar.

The caverns presented us with coarse stalactites, some of which were six feet in diameter; and interesting specimens were obtained containing recent land shells, which had been enclosed while hibernating.‡

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channels are narrow, or few in number, although the lagoon be of great size and depth, (as in Suadiva,) there are no ring-formed reefs; where the channels are somewhat broader, the marginal portions of reef, and especially those close to the larger channels are ring-formed, but the central ones are not so: where they are broadest, almost every reef throughout the atoll is more or less perfectly ring-formed. Although their presence is thus contingent on the openness of the marginal channels, the theory of their formation, as we shall hereafter see, is included in that of the parent atolls, of which they form the separate portions."

* Darwin, op. cit., p. 39.

† For a sketch of this island, see Narrative Exp. Exp., vol. i, p. 338.

‡ It is probable that more extensive caverns would have been found, had there been more than a few hours for the examination of the island. The Rev. Mr. Williams, in his work on Missionary Enterprises in the Pacific, gives very interesting

The surface of the island is singularly rough, owing to erosion by rains. The paths that cross it wind through narrow passages among ragged needles and ridges of rock as high as the head, the peaks and narrow defiles forming a miniature model of the grandest Alpine scenery. There is but little soil, yet the island is covered with trees and shrubbery.

The shores, at the first elevation of the island, must have been worn away to a large extent by the sea; and the cliff and some isolated pinnacles of coral rock still standing on the coast are evidence of the degradation. But at present there is a wide shore platform of coral reef, two hundred or two hundred and fifty feet wide, resembling that of the low coral islands, and having growing coral as usual about its margin and in the shallow depths beyond.

In the face of the cliff there are two horizontal lines, along which cavities or caverns are most frequent, which consequently give an appearance of stratification to the rock, dividing it into three nearly equal layers.

We might continue this account of coral reefs and islands, by particular descriptions of those visited by the Expedition. But the similarity among them is so great, and their peculiarities are already so fully detailed, that this would amount only to a succession of repetitions. And moreover the facts will be found in the geographical report by Captain Wilkes, and are to a great extent well exhibited on the map of the Paumotus and on the other valuable charts of the Expedition. The characters of a few briefly stated will suffice in this place. We commence with the smallest.

Jarvis's Island.—(Fig. 4, page 28.) Lat. 0° 22′ S. Long. 159° 31′ W. Length $1\frac{3}{4}$ miles trending east and west. No lagoon. Shape triangular. A low sandy flat, eighteen or twenty feet high, without trees, and partly covered with small shrubs. A high sloping beach continuous around. Trends east and west. We did not land on this island.

Birnie's.—Lat. 3° 35′ S. Long. 171° 39′ W. Four-fifths of a mile by one-third, trending northwest. No lagoon. A sandy flat about ten feet high, except near the north-northeast extremity,

descriptions of caverns in the *elevated* coral rock of Atiu, one of the Hervey Group.* In one, he wandered two hours without finding a termination to its windings, passing through chambers with "fretwork ceilings of stalagmite and stalactite columns, which, 'mid the darkness, sparkled brilliantly with the reflected torch-light." This author remarks, "that while the madrepores, the brain, and every other species of coral are full of little cells, these islands, (including those resembling Atiu,) appear to be *solid masses of compact limestone, in which nothing like a cell can be detected.*"

Beechey, in his description of Henderson Island, another of this character, speaks of the rock as *compact, and having the fracture of a secondary limestone.*

* Wateoo of Cook.

where it is about twelve feet. To the south-southwest the submerged reef extends out nearly a mile, over which the sea breaks. Distinguished no vegetation except the low purslane and some trailing plants. Did not land.

Swain's.—(Fig. 3, page 28.) Lat. 11° 10′ S. Long. 170° 52′ W. 1¼ miles by ⅔; shape nearly rectangular; trends east and west. No lagoon, but the centre a little lower than the sides. Surface covered with shrubbery and large trees, among the latter many cocoanuts; the centre more sparsely wooded. Height fifteen to eighteen feet, excepting on the middle of western side, where the surface is covered with loose fragments of coral of small size; there appears to have been a former entrance to the lagoon at this place. Shore reef or platform, one hundred yards in average width, and one hundred and fifty yards at the place where we landed. Beach high, ten to twelve feet. At lower part of beach for a height of two to three feet, the coral reef rock was exposed, indicating an elevation of the island. For three or four feet above this, layers of the beach sandrock were often in view, consisting of coral pebbles firmly cemented, and having the usual dip of seven or eight degrees seaward; in many places it was concealed by the beach sands and pebbles. There was no growing coral on the platform excepting Nullipores. The outer margin of this platform was very uneven, and much intersected by channels, though less so than at Enderby's Island.* Great numbers of Birgi, (large Crustacea,) were burrowing over the island, some of which were six inches in breadth.

Otuhu, Paumotu Archipelago.—14° 5′ S. 141° 30′ W. 1½ miles by ⅔, trending north and south. No lagoon. Wooded.

Margaret, Paumotu Archipelago.—20° 42′ S. 143° 4′ W. Diameter one mile, nearly circular. A small shallow lagoon with no entrance. Northeast side alone wooded, and in two patches.

Teku or *Four Crowns*, Paumotu Archipelago.—20° 28′ S. 143° 18′ W. Diameter 1½ miles, nearly circular. A small lagoon with no entrance. Southwestern reef bare; five patches of forest on the other part.

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* The sea was quite heavy when we attempted to land at low tide upon the edge of the shore platform. As we pulled towards the reef, an anchor was dropped, as usual, some distance out, to hold on and save the boat, from being carried by the surges against the rocks. After some heavy seas had passed, a partial lull seemed to favor, and the boat was pulled in. Taking advantage of the favorable moment, I jumped out, and made rapid speed over the reef to escape the breakers which followed. Soon turning about, I was surprised to find the boat just behind me, and the crew in the water alongside trying to steady her and save her from destruction. The man who held to the anchor behind had let go his hold, and the next sea, as it came careering on, had borne the boat over the edge of the reef, and far on its surface. With even greater risk, after our ramble was completed, we succeeded in launching again and reached the open sea. This was one of many similar dangers experienced in these seas.

Washington Island.—Lat. 4° 41′ N. Long. 160° 15′ W. 3 miles by 1½, trending east and west. It is a dense cocoanut grove with luxuriant shrubbery. No lagoon. The shore platform is rather narrow. A point of submerged reef one and a half miles long stretches out from southwest end. Could not land on account of bad weather.

Enderby's.—3° 8′ S. 171° 16′ W. 2¾ miles by 1 mile nearly, trending N. N. W. and S. S. E.; form trapezoidal or nearly rectangular. Little vegetation on any part, and but few trees. The lagoon very shallow and containing no growing coral; its shores a coral mud, allowing the foot to sink in eight or ten inches, and covered in places with saline incrustations. Shore platform one hundred feet or less in width, and surface inclined outward at a very small angle; covered with three or four feet of water at high tide, and with few corals or shells; beyond this, falls off four to six feet, and then the bottom gradually inclines for one hundred yards or more. The beach very high and regular; rises eight feet, at an inclination of thirty to thirty-five degrees; then horizontal for eighty to two hundred, after which another rise of three or four feet. It consists below of pebbles and fine sand, but above of slabs and blocks of coral rock and the beach sandrock, those of the latter nearly rectangular and flat. This beach sandrock occurs in layers from ten to twenty inches thick along the shore, and is inclined from five to seven degrees seaward. Some portions are very compact, and ring under the hammer, while others enclose fragments of different sizes to a foot or more in diameter. The most common coral of the beach was an Astræa with small cells, (near A. cerium, D.—the specimens were afterwards lost.) There were also other Astræas, a large lamellar Madrepore, (M. cyclopea,) some fragments of which were six feet square and three inches thick; also Meandrinæ, Porites, &c. Large trunks of transported trees lay upon the island, one of which was forty feet long and four in diameter. The shore platform was much intersected by channels.

Captain Hudson obtained soundings half a mile off in two hundred fathoms; the lead struck upon a sandy bottom but was indented by coral.

Honden, or *Henuake*, Paumotu Archipelago.—Size 3½ miles by 2 miles. Oblong, five-sided; trending west-northwest. A small shallow lagoon, communicating with the sea only at high tide, on the west side. There are two other entrances, which are seldom if ever covered with water, and appeared merely as dry beds of coral rock. Height of the island, twelve feet: lowest on the south side. Belt of verdure complete, and consisting of large forest trees, with the Pandanus and other species, but no cocoanuts; its breadth ½ mile, and in some parts ¾. Among the trees, large masses of coral rock often exposed to view, and the

surface in many parts very rough. It seemed surprising at all these islands to find so luxuriant a growth of trees and shrubbery over so rocky a surface. Shores of the lagoon nearly flat. On one side there was a large area of extremely fine coral sand and mud, which extended a long distance into the lagoon. Elsewhere about the centre of the island, the reef-rock was bare, and contained numerous shells of Tridacnæ. A few small Madrepores still growing in the lagoon. Beach on the sea-shore side eight feet high. In lower part of beach, several layers of white limestone, (the beach sandrock,) formed of coral fragments or sand, shells, &c., much of which was very compact. The layers inclined towards the sea at an angle of about five degrees. Shore platform as elsewhere in this archipelago.

The facts above stated are evidence of a slight elevation, not exceeding two or three feet.

Taiara, or *King's*, Paumotu Archipelago.—15° 42′ S.; 144° 46′ W. $2\frac{3}{8}$ miles by $1\frac{3}{4}$, trending northwest. A small lagoon with no entrance. Reef almost continuously wooded around, somewhat broken into patches.

Maraki, Tarawan or Kingsmills Group.—5 miles by 2, and having a lagoon. Trending north. Shape oblong triangular. Belt of forest complete. Appearance of a former entrance to the lagoon on the east side.

Whytuhu, one of the two Disappointment Islands, Paumotu Archipelago.—14° 10′ S., 141° 24′ W. $5\frac{1}{2}$ by 2 miles, trending northwest. The reef fronting northeast almost continuously wooded. On the opposite side, three islets, one of rather large size. Lagoon with no entrance.

Sydney Island.—Lat 4° 20′ S. Long. 171° 15′ W. Trends northeast and southwest. Well wooded nearly all round; but on leeward side the forest in patches, with breaks of bare coral. Lagoon narrow, without entrance. Width of island from sea to lagoon, one hundred to four hundred yards: width greatest at south end. Beach ten feet high. The soil of the island consisted of coral fragments and sand. Shore platform fifty to eighty feet wide; five or six feet water over it at high tide. Cut up very irregularly by channels three to eight or ten feet wide. Observed small corals growing on the bottom outside of the platform. Shores of lagoon shallow for fifty yards, and consisting of coral sand. Beyond this a slope covered with growing corals. The corals rather tender species of Madrepores. In the interior of the lagoon many knolls and large patches of coral.

Duke of York's.—8° 38′ S., 172° 27′ W. Form irregularly oblong, trending northwest. Length $3\frac{3}{4}$ miles; breadth 2 miles. Circuit $9\frac{1}{2}$ miles, and about one half wooded in patches. Southwest reef mostly bare. A lagoon, but without entrance except for canoes at high tide, on leeward side. Island ten feet high.

Shore platform narrow, and intersected by channels. Shores lined by reef-rock, two or three feet out of water, indicating an elevation of the island. This reef-rock consists of various corals firmly cemented. Within the lagoon, knolls of coral, but none near the shore on the leeward side.

Fakaafo or *Bowditch's.*—9° 20′ S., 171° 5′ W. 6¾ miles by 4. Shape nearly triangular. Circuit seventeen miles, about six of which are wooded in several patches, separated by long bare intervals. A large lagoon, but no ship entrance. Height of island, fifteen feet. Width to the lagoon, one hundred to two hundred yards. Soil of the island coral sand, speckled black with results of vegetable decomposition. Shore platform narrow. At outer edge a depth of three fathoms, and from thence gradually deepens, and abounds in fine corals for fifty yards, when it deepens abruptly. Coral reef-rock elevated three or four feet, indicating an elevation of the island. Lagoon shallow, with some growing coral, but none near the shore. Some corals growing on the platform, near its margin, mostly small Madrepores, Astræas, Nullipores. Fragments of pumice were found among the natives, which had floated to the island.

Ahii, or *Peacock's Island*, Paumotu Archipelago.—14° 30′ S., 146° 20′ W. 13 miles by 6, trending N. E. by E. Shape irregularly oblong. A large lagoon, having an entrance for small vessels on the west. Reef wooded throughout nearly its whole circuit. Lagoon shallow, and much obstructed by growing coral, the latter giving the water over it a clear light green color. Platform, or outer coral shelf of the island, about two hundred and fifty feet wide; under water except at the lowest tides. Margin highest, and covered with Nullipore incrustations, which give it a variety of delicate shades of color, mostly reddish, or peach-blossom red, rose, scarlet. For thirty to fifty feet from the margin, very cavernous, and containing many Tridacnæ, lying half imbedded, with the variously tinted mantle expanded when the surface is covered with water. Rock of the platform either a compact white limestone or a solid conglomerate; dead over its surface, excepting a few Madrepore tufts or Astræas near the margin in pools. In this shelf there were long fissures, extending nearly parallel with the shore, a quarter to half an inch wide at top, and continuing sometimes a fourth of a mile or more. These fissures were commonly filled with coral sand. The higher parts of the island either consisting of loose blocks of coral or covered with some soil; the soil mostly of comminuted coral and shells, with dark particles from vegetable decomposition intermingled. On the bottom exterior to the shore platform, observed the same corals growing as occurred in fragments upon the island; but the larger part of the bottom was without coral, or consisted only of sand.

Raraka, Paumotu Archipelago.—16° 10′ S., 145° W. 14 miles by 8, trending east and west. Shape somewhat triangular. North side nearly continuously wooded: south angle and south-west reef bare. A large lagoon with an entrance for small vessels on the north side. A rapid current flows from the entrance, which it was difficult for a boat to pull against. Shore platform, as usual, about a hundred yards wide, with the edge rather higher than the surface back; the platform mostly bare of water at low tide. Several large masses of coral and coral rock, one to four hundred cubic feet, on the platform and upon the higher parts of the island, some of which stood five and six feet above high-water mark; they were cemented to the reef-rock below, and appeared like projecting parts of the reef. Layers of beach sandrock on the lagoon shores, as well as on the seaward side, inclined at an angle of six or seven degrees: characters as already described. Growing coral in the entrance to the lagoon, within two feet of the surface, mostly a species of Millepora, (M. squarrosa.) Interior of the lagoon not examined for want of time. The water looked as blue as the ocean, and was much roughened by the winds.

Kawehe, or *Vincennes Island*, Paumotu Archipelago, 15° 30′ S., 145° 10′ W. 13 miles by 9, trending north-northwest. Shape irregularly oval. Having a large lagoon, and mostly wooded around, least so to leeward. Between the wooded islets, (as on Raraka and elsewhere,) surface consisted of angular masses of coral rock, (among which the Porites prevail,) strewed in great numbers together; and in some parts bearing a few vines and purslane among the blocks, though scarcely any appearance of soil, or even of coral sand. In other parts, not as high, no vegetation, and surface still wet by high tide. A few large masses of coral on the shore platform, either lying loose, or firmly attached below; some of them were six feet cube, and one was raised seven feet above high-water mark. Those that were attached were so firmly cemented to the reef-rock as to seem to be a part of it, and they were partly worn off below by the wash of the sea; the surface was extremely rough, owing to wear by rains. These masses were sometimes single individual corals, and others were conglomerate in character. Shore platform about a hundred yards wide, rather highest at the edge, and much of its surface two to four feet under water at low tide. As elsewhere, this platform is nothing but a compact coral conglomerate or limestone, having no growing coral over it, except in some shallow pools near its outer margin, where also there are numerous holes in which crabs are concealed, with small fish and other animals of the shores. On the lagoon shore, layers of beach sandrock, six or seven in number, dipping at an angle of seven degrees towards the lagoon, and outcropping one from beneath the other. Similar layers on the sea-shore side.

Manhii, *Wilson's* or *Waterlandt*, Paumotu Archipelago, 14° 25′ S., 146° W. 15 miles by 6, trending E. N. E. A large lagoon with a deep entrance on the west side. Shape oblong triangular.

Shore platform as usual; mostly under water at low tide. Large masses of coral here and there, standing on this reef, either cemented to it or loose. One top-shaped mass is figured on p. 34. High water did not reach the part of it which was most worn; and this was evidently owing to the fact that the action of the swell, or waves, is greatest above the actual level of the tide at the time. This mass was not of fragmentary composition; it was apparently the remains of a single individual Porites. Another loose mass was five and a half feet high, and averaged ten feet across, (fig. 3, p. 35.) It consisted of large masses of Astræas, Madrepores, and Porites cemented together, and contained imbedded shells, an Astræa, Cypræa, &c. The reef-rock is either a compact limestone showing no traces of its composite origin, or a conglomerate. Beach, regular as usual, 6 to 10 feet high, consisting of coral sand, and fragments of worn shells, with occasional exuviæ of crabs, remains of Echini, fish, &c. The entrance to the lagoon is deep and narrow, with vertical sides.

Aratica or *Carlshoff*, Paumotu Archipelago, 15° 30′ S., 145° 30′ W. 17 miles by 10, trending N. E. Large lagoon, with a good entrance for vessels. The reef fronting south, bare for nine miles: on northwest side, mostly very low, with only here and there a clump of trees; occasionally a line of wooded land for a quarter of a mile on the east side; more continuously wooded on the north. The bare parts, mostly covered with blocks of coral, 1 to 30 cubic feet, and larger, tumbled together, as on the preceding. Some blocks of coral on the shore platform very large; one 8 feet high and 15 in diameter, containing at least 1000 cubic feet; it lay on the reef and was not connected with it; below it, the platform was 6 inches higher than the surface either side, owing to the action of the sea. These blocks are in all instances rough angular, and appear as if they had been thrown up by the sea, and left exposed to wear from the rains and spray.

Nairsa or *Dean's*, Paumotu Archipelago, 15° S., 148° W. 44 miles by 17, trending W. N. W. Northern shore mostly wooded; southern with only an occasional islet, connected by long lines of bare reef. In these intervals, the reef stood eight feet or so out of water, and was worn into a range of columns, or excavated with caverns, so as to look very much broken, though quite regularly even in the level of the top line.

We might continue these descriptions; but the above, with the details before given, will convey a general idea of the whole.

C. The Completed Coral Island.

The coral island in its best condition is but a miserable residence for man. There is poetry in every feature: but the natives find this a poor substitute for the breadfruit and yams of more favored lands. The cocoanut and Pandanus are, in general, the only products of the vegetable kingdom afforded for their sustenance, and fish and crabs from the reefs their only animal food. Scanty too is the supply; and infanticide is resorted to in self-defence, where but a few years would otherwise overstock the half-a-dozen square miles of which their little world consists.

Yet there are more comforts than might be expected on a land of so limited extent,—without rivers, without hills, in the midst of salt water, with the most elevated point but ten feet above high tide, and no part more than 300 yards from the ocean. Though the soil is light and the surface often strewed with blocks of coral, there is a dense covering of vegetation to shade the native villages from a tropical sun. The cocoanut, the tree of a thousand uses, grows luxuriantly on the coral-made land, after it has emerged from the ocean; and the scanty dresses of the natives, their drinking vessels and other utensils, mats, cordage, fishing-lines, and oil, besides food, drink, and building material, are all supplied from it. The Pandanus or screw-pine flourishes well, and is exactly fitted for such regions: as it enlarges and spreads its branches, one prop after another grows out from the trunk and plants itself in the ground; and by this means its base is widened and the growing tree supported. The fruit, a large ovoidal mass made up of oblong dry seed, diverging from a centre, each near two cubic inches in size, affords a sweetish husky article of food, which, though little better than prepared corn stalks, admits of being stored away for use when other things fail. The extensive reefs, abound in fish which are easily captured, and the natives, with wooden hooks, often bring in larger kinds from the deep waters. From such resources a population of 10,000 persons is supported on the single island of Taputeouea, whose whole habitable area does not exceed six square miles.*

Water is to be found commonly in sufficient quantities for the use of the natives, although the land is so low and flat. They dig wells five to ten feet deep in any part of the dry islets, and generally obtain a constant supply. These wells are sometimes fenced around with special care; and the houses of the villagers, as at Fakaafo, are often clustered about them. On Aratica (Carls-

* There are a few islands better supplied with vegetable food, though the above statements are literally true of a large majority.

hoff) there is a watering place 50 feet in diameter, from which our vessels in a few hours obtained 390 gallons. The Tarawan Islands are generally provided with a supply sufficient for bathing, and each native takes his morning bath in fresh water, which is esteemed by them a great luxury. On Taritari, as Mr. Hale was informed by a Scotch sailor taken from the island, by the name of Gray, there is a long trench or canal, described by him as several miles long, and two feet deep. They have *taro* plantations, which require a large supply of water, besides some breadfruit. These islands have been elevated a little, but are not over fifteen feet above the sea.*

The only source of this water, is the rains, which, percolating through the loose surface, settle upon the hardened coral rock that forms the basis of the island. As the soil is white or nearly so, it receives heat but slowly, and there is consequently but little evaporation of the water that is once absorbed.

These islands moreover enclose ports of great extent, many admitting even the largest class of vessels: and the same lagoons are the pearl fisheries of the Pacific.

An occasional log drifts to their shores, and at some of the more isolated atolls, where the natives are ignorant of any land but the spot they inhabit, they are deemed direct gifts from a propitiated deity. These drift-logs were noticed by Kotzebue, at the Marshall Islands, and he remarked also that they often brought stones in their roots. Similar facts were observed by us at the Tarawan Group, and also at Enderby's Island and elsewhere.

The stones at the Tarawan Islands, as far as we could learn, are generally basaltic, and they are highly valued for whetstones, pestles, and hatchets. The logs are claimed by the chiefs for canoes. Some of the logs, like those at Enderby's Island, were forty feet or more long.

Fragments of pumice and resin are transported by the waves to the Tarawan Islands. We were informed that the pumice was gathered from the shores by the women, and pounded up to fertilize the soil of their taro patches; and it is so common that one woman will pick up a peck in a day. Pumice was also met

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* The Scotchman (Gray) from whom this information was obtained, added that ten ships of the line might water there, though the place was not reached without some difficulty. There were fish in the pond which had been put in while young. The bottom was adhesive like clay. He spoke of the taro as growing to a very large size, and as being in great abundance; it was planted along each side of the pond.

Kotzebue observes, that "in the inner part of Otdia [one of the Marshall Islands] there is a lake of sweet water; and in Tabual, of the group Aur, a marshy ground exists. There is no want of fresh water in the larger islands; it rises in abundance in the pits dug for the purpose."—*Voyage*, London, 1821, iii, 145.

with at Fakaafo. Volcanic ashes are sometimes distributed over these islands, through the atmosphere; and in this manner the soil of the Tonga Islands is improved, and in some places it has received a reddish color.

The officers of the Vincennes observed several large masses of compact and cellular basalt on Rose Island, a few degrees east of Samoa: they were lying two hundred yards inside of the line of breakers. The island is uninhabited, and the origin of the stones is doubtful; they may have been brought there by roots of trees, or perhaps by some canoe.

Notwithstanding the great number of coral islands in the Paumotu Archipelago, the botanist finds there, as Dr. Pickering informs me, only twenty-eight or twenty-nine native species of plants. The following are the most common of them:—

Portulacca, two species.	Pemphis acidula.
Scævola Konigii.	Guettarda speciosa.
Pisonia? one species.	Triumphetta procumbens.
Tournefortia sericea.	Suriana maritima?
Pandanus odoratissimus.	Convolvulus, one species.
Lepidium, one species.	Urtica, one or two species.
Euphorbia, one species.	Asplenium nidus.
Morinda citrifolia.	Achyranthus, one species.
Boerhavia, two species.	A species of grass.
Cassytha, one species.	One or two rubiaceous shrubs.
Heliotropium prostratum.	Polypodium.

On Rose Island Dr. Pickering found only the *Pisonia* and a *Portulacca*. The *Triumphetta procumbens*, a creeping plant, takes root like the Portulacca, in the most barren sands, and is very common. The *Tournefortia* and *Scævola* are also among the earliest species. The *Pisonia*, a tree of handsome foliage, the *Pandanus* or Screw-pine, and the *Cocoanut*, (always an introduced species,) constitute the larger part of the forests. In the Marshall Group, where the vegetation is more varied, Chamisso observed fifty-two native plants, and in a few instances the Banana, Taro, and Breadfruit.

The language of the natives indicates their poverty, as well as the limited productions and unvarying features of the land. All words like those for mountain, hill, river, and many of the implements of their ancestors, as well as the trees and other vegetation of the land from which they are derived, are lost to them; and as words are but signs for ideas, they have fallen off in general intelligence. It would be an interesting inquiry for the philosopher, to what extent a race of men placed in such circumstances are capable of mental improvement. Perhaps the query might be best answered by another, How many of the various arts of civilized life could exist in a land, where shells are the

only cutting instruments,—the plants in all but twenty-nine in number,—but a single mineral,—quadrupeds none, with the exception of foreign mice,—fresh water barely enough for household purposes,—no streams, nor mountains, nor hills? How much of the poetry or literature of Europe would be intelligible to persons whose ideas had expanded only to the limits of a coral island;—who had never conceived of a surface of land above half a mile in breadth,—of a slope higher than a beach,—of a change of seasons beyond a variation in the prevalence of rains? What elevation in morals should be expected upon a contracted islet, so readily over-peopled that threatened starvation drives to infanticide, and tends to cultivate the extremest selfishness? Assuredly there is not a more unfavorable spot for moral or intellectual development in the wide world than the coral island, with all its beauty of grove and lake.

These islands are exposed to earthquakes and storms like the continents, and occasionally a devastating wave sweeps across the land. During the heavier gales, the natives sometimes secure their houses by tying them to the cocoanut trees, or to a stake planted for the purpose. A height of ten or twelve feet, the elevation of their land, is easily overtopped by the more violent seas; and great damage is sometimes experienced. The still more extensive earthquake-waves, such as those which have swept up the coast of Spain, Peru, and the Sandwich Islands, would produce a complete deluge over these islands. We were informed by both Gray and Kirby, that effects of this kind had been experienced at the Tarawan Islands; but the statements were too indefinite to determine whether the results should be attributed to storms or to this more violent cause.

The preceding pages have been occupied with a simple description of the actual condition, structure, and appearances of reefs and reef islands. From this review of their existing features, we may pass on to the consideration of those agencies by which these features were produced, tracing out the steps in the progress of such formations, and the influence of various causes on their forms and distribution. We may commence with a brief account of the living zoophyte, its habits and its mode of growth,—as some knowledge on these points is essential to the correct appreciation of the discussion before us. This branch of the subject has been treated of at length in another volume, to which reference may be made for fuller details.*

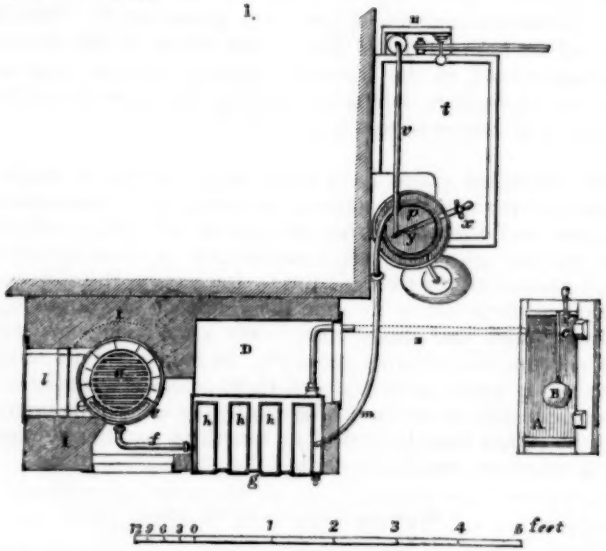
* Report on Zoophytes, by the author.

ART. VII.—*A description of a new Sand-Bath with Water-Bath and Distilling Apparatus attached, erected in the Yale Analytical Laboratory;* by Prof. JOHN P. NORTON.

THIS Sand-Bath was constructed and brought into active employment during the last term in Yale College. Its operation, with that of all its connected parts, has proved so entirely satisfactory, that it has been thought worthy of a notice in this place. There is nothing particularly novel in any one feature, but the combination of conveniences is such as I have never seen equalled, even in the best European laboratories.

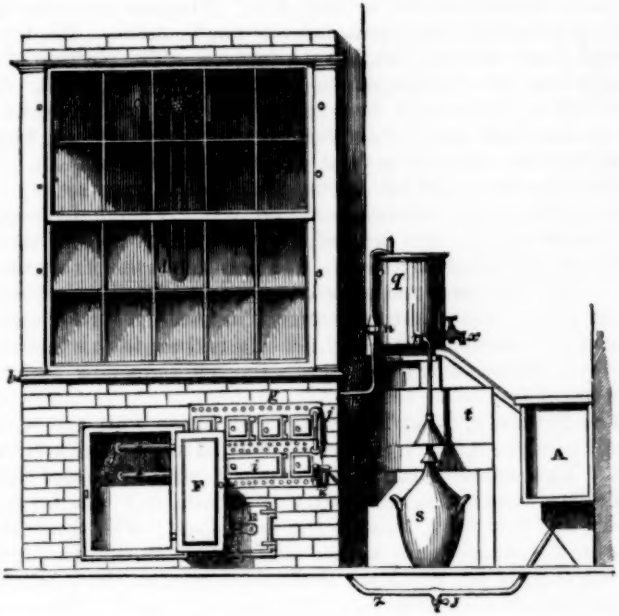
The idea of uniting with the advantages of the sand-bath, those of the water-bath and distilling apparatus, and of accomplishing the working of the whole by means of a single fire, is one that I had before entertained. I long hesitated to attempt its realization, because no model existed; my success in the experiment has however been so complete, that it seems a favor to the chemists of the country, to give such a description as shall enable those who have occasion to build, to adopt an arrangement which possesses the recommendations of efficiency, compactness, and economy of fuel, while at the same time it may be considered almost self-acting.

1.

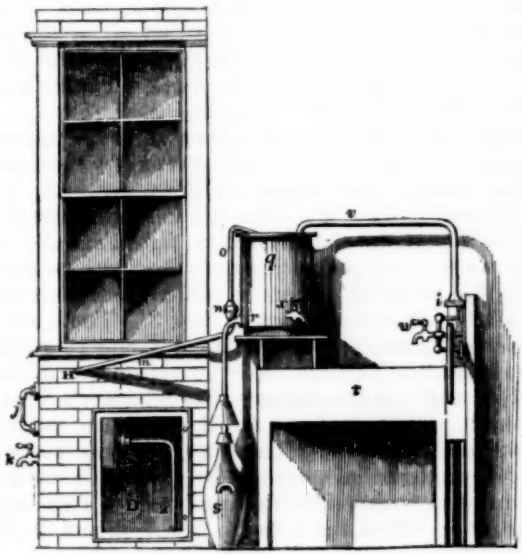


The accompanying plans and elevations, in figures 1 to 3, will I think with some short comments, sufficiently explain the construc-

2. Front elevation.



3. Side elevation.



tion and connection of the several parts. They are all drawn accurately to a scale, so that measurements may be taken. No. 1 is the ground plan. In this plan, *a* is the furnace. The position of this furnace may also be seen at *a* in the front elevation, fig. 2. The sand-bath as represented here and in fig. 3, is similar to one put up in the New York Free Academy by Prof. Wolcott Gibbs; from that one this and several others have been copied. The original however, and all of the other copies were simply sand baths. The lower windows slide up, weights being included in the corner pillars; the heat of the fire passes through the bed plate *b b*, fig. 2, heating the sand which lies upon its upper surface. All noxious fumes are conveyed away by the ventilator *c*, fig. 2, which opens into a chimney flue and may be closed or opened at pleasure by the chain *d*. It is then to this sand bath by Prof. Gibbs, that I have made the additions now to be described.

The furnace *a*, is an iron pot, lined inside with fire brick as usual, except *e e*, fig. 1, where is inserted a water-back of large size. This communicates by the pipe *f*, with the water bath *g*. There are two of these pipes, one above, and one below, as shown at *f f*, in fig 2, through the open door. The front elevation of the water bath, which is of copper in all its parts, is shown at *g*, in fig. 2. Each of the doors seen on the front, opens into a separate compartment. The depth of these compartments is shown by the sections *h h h*, in fig. 1. At *i*, fig. 2, is a larger compartment, for receiving articles of considerable size.

At *j* is a glass tube to show the height of water in the water bath, and at *k*, a cock placed so low that all of the water contained may be drawn off, thus removing any small quantity of sediment which occasionally accumulates. These two parts are seen more clearly at *j* and *k*, in fig. 3.

The furnace is fed through a door at *l*. A moderate fire is sufficient to establish a brisk circulation through the pipes *f f*, and causes the water to boil violently in the water bath, keeping it always fully up to 212° F. The steam formed escapes through the pipe *m*, fig. 1, also shown at *m m*, figs. 2 and 3. At *n*, figs. 2 and 3, is a coupling connecting the copper pipe *m*, with a block tin pipe *o*, figs. 2 and 3, and worm *p*, fig. 1. This worm is contained in the condenser *q*, figs. 2 and 3. The distilled water thus produced, escapes at *r*, figs. 2 and 3, and runs into the receiver *s*, beneath. The condenser stands on a shelf over a sink *t*, figs. 1, 2, and 3, at the farther end of which is a force pump *u*, figs. 1 and 3. A pipe *v*, figs 1 and 3, runs from the top of this pump into the condenser. The pump delivers cold water into the sink in the common way, but by closing the cock at *w*, fig. 3, will throw its stream into the condenser. This water when warm is drawn off at the cock *x*, figs. 1, 2, and 3. The pipe

from this cock seen at *y*, fig. 1, rises to within an inch or two of the top of the condenser, so that the warm water is drawn off first. By this arrangement the very great convenience is obtained of a constant supply of hot water, delivered into the sink for washing.

As the well water at New Haven contains a considerable amount of solid matter, which soon encrusts the interior of vessels in which it is steadily boiled, rain water only is used in the water-bath. The supply is kept up through the pipe *z*, as shown in figs. 1, 2 and 3, running under the floor. Its whole course may be traced by these three figures. It rises into the box A, figs. 1, and 3, in which the water stands on a level with the upper part of the glass guage tube, show at *j* in fig. 3. Upon the surface floats a large hollow copper ball, B, fig. 1. As soon as the formation of steam and its consequent passing off into the condenser commences in the water bath, the surface of course lowers, and a corresponding lowering occurs in the box A. The copper ball, B, sinks with the water, and gradually opens a valve at C, fig. 1. This admits a stream of water from an elevated cistern, which flows in just fast enough to supply that which passes off from the water bath as steam.

This arrangement is only novel in its present application, being I believe quite common in some of our cities for regulating the flow of water into cisterns. It works admirably in the present case, and seldom if ever requires any attention. If the fire is very hot, so much steam is occasionally generated, that it is not condensed with sufficient rapidity; a partial flow of hot water back into the box A, has several times occurred under these circumstances, but has never been sufficient to overflow. This difficulty might be avoided by enlarging the conducting pipe *m*, and the worm *p*, or by reducing the size of the water-back *e*, *e*, fig. 1.

The space D, fig. 1, is a large dry hot oven, where quite a high heat is obtained. This is also shown at D, the door being taken off. In this oven a shelf is placed, perforated with holes for the insertion of funnels, tubes, &c. It is in constant use for drying, and is found to be of very great service in all cases where rapid drying is desirable, and a precise temperature is not required. The small door at E, fig. 2, is another means of access to this oven.

The water-bath is set in the brick work, but may be taken out and reset without disturbing the rest of the apparatus, in fact every part is accessible. The couplings to the pipes *f*, *f*, may be reached through the door F; those to the supply pipe *z*, at G, fig. 3, those to the escape pipe, *m*, by taking out a brick at H, fig. 3. In order to obtain ready access to the interior of the furnace pot *a*, there is a large moveable circular plate immediately above; its circumference is shown by the dotted line at I, I, in fig. 1.

The supply of water from the cistern to the box A, is cut off by a stop-cock at the cistern, and the water may be entirely drawn off from the box, by a small cock at J, under the floor.

It will be perceived that this arrangement is compact and simple. There is no part liable to get out of order, or that once out of order, cannot be easily reached for the purpose of repairs.

By means of one fire, and that not large, we heat the sand-bath sufficiently, maintain a large water bath constantly at 212° F., make from ten to fifteen gallons of perfectly pure water per day, heat a large drying oven, and keep a constant supply of hot water over the sink for washing. Everything takes care of itself excepting the fire, and the occasional pumping of cold water into the condenser. I am unable, after two months of experience, to suggest any important improvement in these arrangements, and feel confident that any one who should put up a similar apparatus would not be disappointed.

Prof. Porter of Brown University is partially copying after this model for his new laboratory in that institution.

I must here express my obligations to Mr. Culver, of the firm of Culver & Cory, New York. His practical skill enabled me to overcome several difficulties which at first appeared quite formidable. Nearly all of the iron and copper work was done in the shop of Messrs. Culver & Cory, and in so substantial and satisfactory a manner, that I can safely recommend them to all who may contemplate putting up anything of the kind I have described. Having the patterns and the experience, they can work cheaper and better than those who have never done any such business. The iron work is all japanned. The glass should be set with a putty made of boiled linseed oil, as that will harden under the heat to which it is exposed; the common putty made with fish oil remains soft, and the glass is constantly liable to get out of place.

Art. VIII.—*On Microscopes and Microscopy.*

Prof. J. D. Dana—*Dear Sir*:—I much regret not being able to communicate to you, before now, some facts on microscopes in answer to the inquiries made. But many circumstances have prevented me, and although this may come at rather a late hour, yet I trust it will prove acceptable since the facts relate to a subject possessing at this time more than ordinary interest.

You are aware that lately I have been somewhat in "the microscopic way," and I think that you will learn most from me, by allowing me to go over that portion of the ground that bears on my personal experience.

Mr. Spencer, the optician, is so well known, and his superior attainments in this department have of late been so often discussed in print, that it is unnecessary for me to mention who he is and what he has been doing. The capabilities of his lenses are well known to our first microscopists, and the occasional articles of Prof. Bailey within the past two years, have shown the opinion of one of our first authorities on this subject. But, with all this, I do not recollect to have seen the result of a comparative trial between Spencer's and the best foreign glasses.* It is to this point that I wish to ask your attention.

Last summer I had the good fortune to obtain from him a set of lenses, which he acknowledged, he would be pleased to have brought into competition with those of Europe. I considered this particularly fortunate, not only on my own account, but because I was then just ready to leave for Europe and should shortly enjoy the opportunity of comparing them, as he desired.

The best foreign instruments seldom reach this country. The makers have always friends at hand who immediately seize upon whatever may be wrought in an eminently superior manner. I therefore thought that if I could reach and address the makers themselves, it would ensure a fair trial to all.

I regret that I was not long enough in London, or sufficiently favorably situated, to take advantage of the many kind inducements offered me to have a comparison there.

In Paris, however, many circumstances tended to hasten a trial, and particularly the presence there at that time of some of the latest, and reputedly the best English lenses. Moreover there were there many amateur microscopists.

The lenses on trial were as follows: those of Mr. Ross, of Messrs. Powell and Lealand, of Messrs. Smith and Beck, of London; those of M. Nachet of Paris; and those of Mr. Spencer of America. I regretted that none of the lenses of M. Oberhäuser —I mean his best—could be obtained at that time.

To secure perfect fairness, the lenses were all adapted to one mounting (a small one of Amici's pattern), and M. Nachet kindly superintended its correct adjustment.

The tests used were the most difficult that could be obtained, and that are now known—*Nobert's lines*, the *Grammatophora subtilissima*, and Amici's test, being a shell, one of the *Naviculæ*, and having markings more difficult to resolve than any other shell as yet discovered, if we perhaps except a Grammatophora, lately found at Providence, R. I. Now it is well known that the markings on the most difficult of organic test-objects can be made out by oblique light only, this obliquity was obtained to almost

* The notice of the trials at Paris, given by Dr. J. L. Smith in vol. xi, p. 277 of this Journal, had not been seen by the author when this was written.—Eds.

any desirable extent, by the use of Amici's prism, which gives a wider angle than the prism of Nachet, or any other similar means used. The claim for superiority was soon found to lie between the lenses of Mr. Ross, Mr. Spencer and M. Nachet. Those of the other English makers were not, I was well convinced at the time, fair specimens of their skill, and as you will soon perceive, a subsequent experience justified this view.

With Nobert's lines it was thought that there was not a very marked difference between the three lenses above mentioned. At any rate as we could not all see alike, it was not regarded as being any especial test in this case.

The markings on both the *Grammatophora* and Amici's test, could be made out by all three, but certainly most distinctly and sharply defined by Ross and Spencer,—the field of Nachet not appearing quite as clear and light.

Between Ross and Spencer on the test of Amici, there did appear to be but very little difference, although I am free to say that if there was a choice of sharpness of definition, it was in favor of Ross.

On the other hand, with the *Grammatophora*, the opinion oscillated as much in favor of Spencer. So that with these two supreme tests, there appeared really to be no particular choice between Spencer and Ross, but as usual in such matters, the owners of the lenses felt no disposition to exchange with each other.

The working of Nachet's lenses, although they did not come up fairly with those of Ross and Spencer, was most excellent; and quite remarkable, considering what has hitherto been attained by the French opticians. Their excellence was also perceived in their great focal length, and other fine working qualities to which I shall soon allude. Moreover, although the results obtained upon organic particles, such as blood and other corpuscles, were in about the same ratio as the other tests, yet with these especially the lenses of Nachet claimed great credit for their clear achromatic power, representing the color of the particles in as nearly their natural condition fully as finely as any lenses I had before seen.

The main result of the trial was, in this case, the same in one particular as in other trials I have made, viz., to elevate our opinions of the capabilities of the lenses employed, it matters not by whom made. And if it was with much astonishment that the French opticians viewed the lenses of Mr. Spencer, I am sure that it was with no less wonder that some of our countrymen present saw the excellent glasses of Nachet. But to all it must be a cause of greater astonishment and admiration, that one self-educated, and who had had none of the experience of Europe, should make lenses fully equalling those of Europe's best artists who have been educated to the trade from their earlier days.

The lenses of Powell and Lealand did not, as I have before said, meet my anticipations; but since then I have met with better, and as bearing upon another comparison of lenses, I will as briefly as possible relate what happened. Some time since while in Philadelphia I had the good fortune to see some very recently imported English lenses, in the possession of microscopists of that city, who are too well versed in these matters to tolerate any but the most superior glasses. Those of this character were from Powell and Lealand.

Another comparative trial being suggested, all the lenses were adapted to a large fine English mounting, and it was thought best to test them by direct light and with the podura-scale, the greatest superiority resting of course upon the clearest and sharpest definition of the markings on that object. The $\frac{1}{11}$th inch objectives were used.

It was evident at first that the angle of aperture of Spencer was wider than that of the others, a larger field and more light being of course the result. As to sharpness of definition the opinions oscillated as at the other trial in Paris, first to one and then to the other, as they always must when lenses of great superiority approach so near to each other. But the impression left at last upon the mind seemed quite in favor of Spencer, as expressed afterwards by one who appeared equally capable and impartial in the matter. "They are fully equal to the best imported objectives I have seen, and I will not say that they are not a little better. I am inclined to believe that they are."

It may seem strange to some, that the direct light was used in this instance as a trial of the lenses. But it appears to me that the merits of a lens are as well if not better exhibited by this as by the indirect illumination. For in this case you have the degree of perfection with which it transmits light, without so much reference to the comparative angle of aperture, as to its capability of separating closely approximate rays emanating from an exceedingly minute yet methodically marked object. Such an object is a good scale from the Podura; and where several microscopists are together and can see the same scale with the different lenses, and can notice the difference of sharpness of definition, the capabilities of the lenses can be very impartially and correctly obtained. Some may urge that with any first class lens, the whole structure of the scale can be made out; this is very true, but this structure admits of being seen with different degrees of distinctness.

Moreover when lenses approach each other pretty closely in excellence, a difference may be perceived in distinctness of definition upon a well known object when seen by *direct* light, whereas that difference might well be disputed if those same lenses were made to bear upon a surface, the markings of which are with the utmost difficulty, or not at all, seen by indirect light.

But there is another reason which I wish to urge in favor of *direct* light being used in comparative trials, where instruments are together. Every one is aware of the fact, that in practising with his own instrument at different times, upon test-objects with *oblique* light, there are at times when with a certain obliquity, the test appears most excellently well brought out, while there are other times when apparently with the same amount of light and obliquity, the test is seen scarcely at all. Now all this arises from a slight yet real difference of the manner in which the object is illuminated, which, although otherwise imperceptible, causes that deficiency of a perfect shadow so essential to a clear definition. Now in a trial of instruments at a distance apart, this mode cannot be pursued, because a difference of distinctness must be *seen* and cannot be expressed; but I am the more persuaded that the comparative superiority of instruments, widely separated and upon different mountings and with dissimilar modes of illumination, cannot be even approximately obtained. I have seen lenses when tried upon a certain mounting cast aside as inferior to others upon a different mounting, whereas, subsequently when they both were put upon a single mounting befitting each, the former were found the superior.

I have thus informed you of the results of the comparative trials of Spencer's lenses at which I have been present; and when we regard the untutored labors of Mr. Spencer as thus coming so successfully into competition with those of the long experience of the first artists of Europe, we may well look upon our countryman with pride.

Before I close I will allude to the general character of microscopes of different makers, as it has appeared to me during the favorable opportunities presented at these different trials.

As a whole, the English instruments are very fine, and from no other makers can be obtained such exquisitely wrought brass mounting, united to quite excellent lenses. But they certainly have the objection of want of simplicity which makes them unwieldy, and almost fixtures wherever they may be placed, and attaches to them a price that places them beyond the reach of many who would use them best.

Moreover I cannot think their mountings so well suited for real work as some others; but they are most excellently adapted for that class of microscopists who are not desirous of being workers so much as of being amateurs in this department of science.

And although there are many times when all the nice mechanical arrangements of an English mounting may be almost indispensable, yet the man who does the real work, and from the labors of whom this science is to progress, will not use them once in a hundred times.

But if complexity is the excelling point with the mountings of English opticians, the opposite is true with those of the French,

for their object appears to have been to combine the greatest simplicity with working qualities.

This is very desirable because it insures several other important conditions, not to mention an incomparable cheapness, thus bringing them within the means of any one who would study this subject; it makes them portable, easily rigged, and not at all liable to derangement with the longest journeyings. But while I say this, let me add, that I think the mounting is rather too simple—in other words, I think it might be so altered, or have additions, that would increase its power of showing the capabilities of lenses, at the same time not infringing upon its working qualities. (Let me here say in parenthesis, that both M. Oberhäuser and M. Nachet are now directing their attention to this point.) I have here referred only to their mountings; their lenses have peculiarities worthy of notice. From what has been said, you will perceive that I do not think the French lenses equal either to the English or to those of Mr. Spencer. In working them they have sought every way to give them *ordinary* working qualities, their angles of aperture are narrow, which insures a long focal distance and a *flatness* of field not often seen in other instruments. This is particularly true of those of M. Oberhäuser, and combined with his *platine tournante*, is the cause of his well-merited success.

This class of instruments have certainly done more than any other for building up microscopical science, (which is not made up of the study of test-objects.) For working qualities upon *ordinary* objects, and particularly in many departments of natural history and pathology, requiring the use of from 300 diameters to quite low powers, they are very desirable, and answer the purpose of most other instruments with but half the cost.*

There are very many people who have a taste for pursuing microscopic studies, but it is not all of these who would like to follow the subject into all its most intricate departments; they would prefer to be pilgrims to a certain extent in the paths others before them have made, rather than pioneers on unbeaten tracks; such do not require the very best instruments.

It appears to me that those who wish to go beyond present microscopy, and investigate points of a very doubtful nature, will not succeed perfectly with the lenses of Oberhäuser or Nachet. Not only because their high powers lack a sharpness of definition, but because their powers are not sufficiently high for such studies. Oberhäuser's highest power is 800 diameters, Nachet's 1100. And even with these the darkness of the field causes them to be seldom used; and I have found these powers not ad-

* In proof of this assertion, I may mention that I saw on M. Oberhäuser's books, more orders for instruments from London and other large cities of Great Britain than elsewhere.

equate to the successful study of some points in Cytogenesis and Spermatology.

In regard to a comparison between the instruments of Oberhäuser and Nachet, I cannot admit, as have some of my friends, the great superiority of the latter over the former, that is, with corresponding powers. Nachet works lenses having some 300 or more diameters more than those of Oberhäuser—besides with his best, the angle of aperture is wider and of course the field larger.

But still I have been unable to perceive that Nachet's lenses have a whiter field, or define objects more sharply than those of his tutor. I found many of the best microscopists and naturalists in Paris, who affirmed that as yet they had not seen fit to give up Oberhäuser for Nachet.

It now remains for me to say a word or two about Mr. Spencer. He is now a rival at least of the best foreign artists, and from what has been said, you cannot think it strange that they are fast acknowledging him as such. He has taken up the subject practically and experimentally, going over the whole ground for himself and learning its complete condition. It has been a source of wonderment to foreign opticians, how he could obtain such wide angles of aperture with his lenses and yet having the generally accompanying errors of chromatism and spherical aberration so carefully corrected; in fact Mr. Ross, in speaking of this subject to me, said, he thought that Mr. Spencer must have some mode of working glass as yet unknown to other opticians.

I think it true that the best English opticians and especially Mr. Ross, have wrought the finest European glass to its utmost capacity. Now the secret of success with Mr. Spencer is, that he makes his own glass, and after much experimenting, he has been so fortunate as to produce a form capable of being wrought with a very wide angle of aperture, yet with no more than the ordinary liabilities to chromatism and spherical aberration. This is the great point to be sought, and in his lenses recently made, I think he has been quite successful, much more so than with those made some three or four years since.

The advantages of such a wide angle of aperture, with a correction of the above errors, cannot be appreciated except by use of the lenses. The size of the field being very much increased, one is able to perceive the whole object instead of a single portion—and when you wish to view all the relations of an object in conjunction, or where it is to be sketched—this is a qualification of much value. Moreover the flood of light that the glass receives, emanating from every part of the object observed, renders the latter very much more distinct, and its structure therefore can be much better made out. This is very noticeable and its great advantage will be quickly perceived in microscopical pathology, in the study of sections of tumors, &c., and in the determination of the structure of minute animals in natural history.

Then again, such an abundance of light removes much obscurity from, and renders the use of, very high powers, quite available. And the power of 1500 diameters with Spencer's lenses is quite as clear and distinct as one-third that number with the French and many English. Every one knows how much better it is to be able to control the amount of light by a diaphragm, than to have the lenses control it for you. These are the grand merits of Mr. Spencer's lenses, which are the better shown off by the very excellent manner in which they (the lenses) are mounted. But with these manifold advantages, there are some disadvantages which have quite naturally resulted from the mode of lens-working pursued by Mr. Spencer. The lens being wrought with an angle of aperture, at the expense of its aplanatism, the focus is made, in the high powers impractically short, so that although, for instance, one may be using or wish to use the $\frac{1}{12}$th objective of 140° or 150° angle of aperture, with the advantages of much light, &c., he will find that scarce any but objects specially prepared with the thinnest of covering glass, can be placed beneath it. With one who wishes to *work* with his lenses this is a serious difficulty, and I have thought, that unless this can be remedied, the possession of high objectives having more than 130° angle of aperture is not desirable for working microscopists. The attention of Mr. Spencer has been directed of late to this point, and it would appear that after some experimenting, he expects to go even *beyond* the solution of this difficulty. In a recent letter, answering some inquiries on this subject, he makes the following remarks:—"The remark you made that an increase of angle of aperture tends to shorten the working focus, is true of the present formulas. I do not remember that I mentioned this subject in a former letter, at any rate, my attention has been turned to it, and sometime since I began an objective under a new formula, the express design of which is to obviate this defect and to secure a working focus—for even a $\frac{1}{30}$th or $\frac{1}{50}$th inch objective, equal to the common $\frac{1}{12}$ths. I think this can be done and retain the maximum angle of aperture. It does not follow that an increase angle of aperture interferes with the corrections of figure and color to such an extent, as to set the skill of the artist at defiance. It doubtless increases the difficulty of *investigation*, and to some extent the *execution*."

Such news is more than welcome to all lovers of microscopic science—and considering what has already been accomplished, we can look forward with both hope and pleasure to the time, not far distant, when complete success shall have crowned the labors of our countryman.

Trusting that the interest of the subject will be something of an apology for the length of this letter, I am yours truly,

W. I. Burnett.

Boston, May, 1851.

Art. IX.—*On the Connection of Chemical Forces with the Polarization of Light;* by Nevil Story Maskelyne, Esq., M.A.*

Any facts which can throw light upon the ultimate molecular structure and condition of chemical compounds, cannot fail of possessing interest of a high character, as well for those whose thoughts only casually dwell upon questions of physical science, as for the mathematician and the chemist. To the mathematician, indeed, they would, if completely unfolded, supply the data for him to undertake the resolution of the questions of chemical combination and chemical change, by treating them as problems involving the action of mechanical laws; to the chemist, the acquisition of such knowledge would be the removal of some of the profoundest difficulties of his philosophy: but such knowledge is only to be sought in the most difficult paths of the whole range of science. The question of the connection of chemical type with crystalline form, the fruitful cause of so much contention among mineralogists as to the questions of mineral species, is one on which we have no complete and sure knowledge; for the facts of dimorphism show, that implicated with this question are the actions of other forces, such as electric condition, and above all the mysterious molecular alterations induced by heat. Another direction in which such inquiries have been pursued, has been in tracing the phenomena resulting from the property possessed by many bodies, of modifying a plane-polarized ray of light, by what is termed circular-polarization. This property, from its being proved to be, in a large number of cases, an expression of the *molecular* structure of the substances, and as such inseparable in many cases from its chemical existence, may be taken, whenever this can be shown to be the case, as an evidence of its individuality, and may be used to determine the question of the permanency or transitory character of the molecular type of the substance. The information thus gained may be but vaguely defined, and the truth but darkly seen, yet does it nevertheless afford a valuable and interesting point of view for studying the molecular nature of bodies.

M. Biot has been for forty years enriching chemico-physical science by a series of memoirs detailing the results of his study of these phenomena. He has there shown the value of this means of tracing changes in chemico-molecular constitution.

M. Pasteur has carried forward this inquiry into a new channel by tracing a connection between this property in substances, of circularly polarizing light, and their crystalline character.

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* Proceedings of the Roy. Soc., London, Monday, March 28, p. 45.

But as it would be impossible to explain the nature of his investigations, or their results, without a preliminary knowledge of the meaning of the terms, "circular polarization," and "hemihedrism," it was necessary first to enter a little upon the explanation of them.

Accordingly a ray was explained as being a direction of light, having no relations to space which differed from each other in directions perpendicular to its length. Thus without complicating the subject, by using the language of the beautiful wave-theory, a ray might be imagined as a cylinder of minutest diameter but indefinite length. When such a ray is reflected at a certain angle from glass or such like substance, it is split into two; one going into, and through the glass if it be not opaque, the other being reflected from it. These two rays no longer possess the same "absence of sides" as the original ray. For the one has been as it were flattened down to a "strip," while the other has also been flattened similarly into a "strip," but the latter strip is at right angles in regard to its "flattened plane" to what the other is. A similar bifurcation of the ray is produced in the interior of what are called doubly refracting crystals. This bifurcation and flattening of the ray is termed "plane polarization" of it; and it is so far a true instance of polarity—as that the two rays have equal and similar properties in opposed directions.

This was exhibited by the lime-light. The double image of a small round hole formed by a crystal of Iceland spar was thrown on a screen, and each beam shown to be most capable of reflection in a plane in which the other was incapable of being reflected at all. The action of the tourmaline as a doubly refracting crystal which absorbs one of the rays was then explained; and it was shown that the position of the tourmaline in which it intercepted one ray entirely, was exactly the position in which it gave the other ray free passage. The optic axis of a crystal was then defined to be a direction in it along which the light could pass through the crystal without undergoing any change whatever. The central ray of a polarized beam of light, traversing a piece of calc-spar along its optic axis, was shown to be intercepted or transmitted by a tourmaline, precisely as if the section of the crystal of calc-spar were away.

An exception was however stated to exist to this law of the neutrality of the optic axis. When a section of quartz, cut so that the beam could career along its optic axis, was put in the path of the polarized ray, it was found that instead of permitting the ray to be eclipsed by the tourmaline when this was placed in the position to eclipse it, that ray on the contrary fell on the screen endowed with beautiful color; and furthermore that the revolution of the tourmaline induced the most brilliant succession of colors, in the order, in the instance exhibited, of red, plum-

color, blue, green, orange, red. It was shown, however, that another specimen exhibited these colors in the reverse order of red, orange, green, blue, plum-color, red; in which order the former specimen of quartz produced these colors when the tourmaline was turned in the *opposite* direction. Hence these are termed right and left-handed polarizations. The whole of these phenomena were attributed to a complicated set of movements of the light within the crystal, the *resultant* of which was practically a rotation of the plane in which the ray was capable of being reflected,—so that the thicker the crystal, the further round the tourmaline had to be turned to permit the ray to pass it, or to be eclipsed, as the case might be. The opposite order of the colors was explained by the fiction of supposing the one to be the effect of a left-handed thread to the screw and the other of a right-handed thread characterizing the spiral in which the plane of polarization was supposed to rotate. Of course this was only a popular way of explaining the phenomenon, it being really due to a more complicated series of movements which were explained by Fresnel in the most triumphant manner by the wave theory.

The color was accounted for by the idea of the red following a longer spiral (having a coarser thread to the screw) than that of the orange, this than the yellow, and so on up to the violet. Without the tourmaline in front all would emerge and form white light; but the tourmaline only allows such rays to pass it as are capable of passing it in its particular position; i. e. only such, the rotation of whose plane has brought them round to the position of the plane in which the tourmaline lets the light through.

The singular fact of amethyst being a combination of alternate layers of right and left-handed quartz was then exhibited, both by throwing the image of the alternate layers on the screen, and afterwards by showing that the general effect of a traversing polarizing beam was to produce a neutrality of action. Other substances, however, produce phenomena of circular polarization. Uncrystallized, fused tartaric acid, and barley sugar, &c., produce them; and these bodies when dissolved, and many more in the form of liquids also, do so, some of which were exhibited. But the silica of which quartz consists entirely loses this property when divested of its crystalline character, whether artificially or in its natural state, as calcedony, opal, &c. All other bodies retain it so long as their chemical molecule retains its individuality of character.

The next point to be made clear, was the meaning of that form of crystallographic development called "Hemihedrism." Haüy's great law was, that similar edges or angles were always similarly modified. The nature of similarity in edges or angles was then pointed out, and the general idea of many crystallographers of a sort of nucleus or primitive form existing on which the crystal

was formed, was explained, as also the nature of the development of such a crystal by the modifications placed on the edges and angles according to the law before mentioned. But the exception to that law was not less remarkable for its generality of character than the law itself. This exception consists in the fact that very often crystals are found in which not every similar edge or angle was modified, but where every *alternate* similar edge or *alternate* similar angle was so. This circumstance was then illustrated by the actual truncation of some models; and it was shown that such alternately developed or *hemihedral* crystals may be *right* and *left*, the upper terminal modification being to the right in the one case, and the corresponding and similar lower terminal modification being then to the left, while in the other case they are exactly the converse. Hence, one crystal is, as Pasteur describes it, "*non superposable*" to the other: the one is as the image of the other reflected in a mirror, as the right hand is compared to the left.

A beautiful connection was then pointed out, as established long ago by the acute observation of Sir J. Herschel, that the plagihedral facettes of quartz indicated, by their relative positions on the crystal, the direction in which the crystal would rotate the plane of polarization. The crystallographic character of these facettes was then pointed out, and their connection shown with this hemihedrism. But the most beautiful instance of the connection of hemihedrism in crystals with the direction of the rotatory power of the substance of which they are composed is afforded by the recent discoveries of Pasteur, which may now be almost traced to a law, enunciated thus: that where a substance is hemihedric when crystallized, and possesses the rotating character, the direction of the rotation is indicated by the nature of the hemihedrism.

Paratartaric acid was then introduced. It was described as extremely like tartaric acid in its chemical reactions and identical with it in composition. It was similarly formed to the latter, and was found only one year in the cream of tartar of the wine of the Vosges. Pasteur separated the crystals of the Paratartrate of soda and ammonia into two several sets; the one set he showed to be hemihedric to the right, the other set to the left. The former proved to be the salt of an acid rotating to the right, the latter of one rotating to the left. On examining these acids they were found in every single property, but this rotation, identical with one another and with tartaric acid. Yet when mixed they formed again the Paratartaric acid, which, like the amethyst, is without any action of a rotatory character, and the difference of which from the other two acids was then exhibited by the precipitation by the latter of a salt of lime which did not render either of the former turbid.

Mr. Maskelyne then detailed the experiments of M. Pasteur on malic and aspartic acids and asparagine, and showed how all of these could be understood to contain chemically a molecular unit common to all these and perhaps to tartaric acid, and only modified a little by the super-position as it were of other substances, in combination with it, upon the extremities of its molecule.

He also dwelt on the possibility of the Paratartaric acid being a quadribasic as the tartaric acid is a bibasic acid: it being on this view a conjugate acid consisting of the two united tartaric acids. He then invited attention to the interesting nature of M. Biot's investigation of the action of tartaric acid in solution in water, and he showed that here the acid must be supposed capable of combining with an indefinite or indeed an infinite amount of water, while in other cases again, bodies (such as sugar for instance) exercise no effect upon the water and do not seem to *combine* with, but only to be dissolved in it. The former is an instance of a *continuous* and not *intermittent* sort of combination: and though we need not anticipate a recurrence of the controversy of Berthollet and Proust, yet this shows us that the actions of quantity or mass so dwelt on by the former are not without a great significance; and that the power that can thus enable us to determine such important points in chemical statics, is well worthy of the attention of the philosophic mind.

Dr. Bence Jones permitted a Saccharimeter apparatus of Soleil's, on the double-quartz-plate principle, to be exhibited, and explained its use. Mr. Tennant also exhibited a mass of quite transparent Iceland spar, and a beautiful crystal of plagihedral quartz.

Since the delivery of the lecture, a letter has been received from M. Pasteur stating that he had forwarded for exhibition at this lecture and in illustration of it, all the finest specimens of the crystals which he has produced, which are further illustrated by models and diagrams. They are the same as those which were exhibited at the Academy of Sciences at Paris, and the liberality of M. Pasteur's act will be appreciated by members of the Royal Institution, when they are reminded that the Paratartaric acid of which they are the products is impossible to be obtained, from its having only once been accidentally formed, and that these specimens therefore consist probably of the only large accumulation of this body in existence.

ART. X.—*On Atmospheric Magnetism;* by Prof. FARADAY.*

ON a former evening (January 24,) it was shown that oxygen gas was magnetic, being attracted towards the poles of a magnet; and that like other magnetic bodies, it lost and gained in power as its temperature was raised and lowered, and that the change occurred within the range of natural temperatures. These properties it carries into the atmosphere; and the object, this evening, was to show how far they might be applied to explain certain of the observed variations of the terrestrial magnetic force.

If a source of magnetic power be considered (as a magnet), it presents us with a system having polarity; and if the parts which are called the poles be taken as representing the most concentrated condition of the polarity, then the contrary polarities, manifest externally in relation to the magnet, are perfectly definite, being exactly equal to each other. If the magnet be irregular in the disposition of its force, still the same definite character of the sum of the contrary polarities holds good.

External to the magnet those concentrations which are named poles may be considered as connected by what are called magnetic curves, or lines of magnetic force, existing in the space around. These phrases have a high meaning, and represent the ideality of magnetism. They imply not merely the directions of force, which are made manifest when a little magnet, or a crystal, or other subject of magnetic action is placed amongst them, but those lines of power which connect and sustain the polarities, and exist as much when there is no magnetic needle or crystal there as when there is; having an independent existence analogous to (though very different in nature from) a ray of light or heat, which, though it be present in a given space, and even occupies time in its transmission, is absolutely insensible to us by any means whilst it remains a ray, and is only made known through its effects when it ceases to exist. The form of a line of magnetic force may vary exceedingly from a straight line to every degree of curvature, and may even have double and complicated curvatures impressed upon it. Its direction is determined by its polarity, the two changing together. Its powers are such, that a magnetic needle placed in it finds its place of rest parallel to it; a crystal of calcareous spar turns until its optic axis is transverse to it; and a wire which is unaffected when moved in or along it, has an electric current evolved the instant that it passes across it: by these and by other means the

* Proc. Roy. Soc., April 11, p. 56.

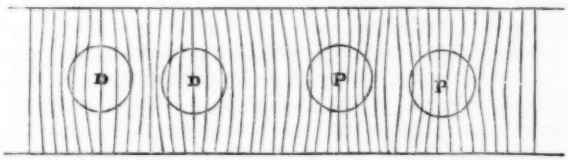
presence of the magnetic line of force and its direction are rendered manifest.

The Earth is a great magnet: its power, according to Gauss, being equal to that which would be conferred if every cubic yard of it contained six one-pound magnets; the sum of the force therefore is equal to 8,464,000,000,000,000,000,000 such magnets. The disposition of this magnetic force is not regular, nor are there any points on the surface which can be properly called poles: still the regions of polarity are in high north and south latitudes; and these are connected by lines of magnetic force (being the lines of direction) which, generally speaking, rise out of the earth in one (magnetic) hemisphere, and passing in varied directions over the equatorial regions into the other hemisphere, there enter into the earth to complete the known circuit of power. A free needle shows the presence and direction of these lines. In London they issue from the earth at an angle of about 69° with the horizon (being the dip or inclination;) and the plane in which they rise forms an angle of 23° W. nearly with true north, giving what is called west declination. Where the dip is small, as at the magnetic equator, these lines scarcely rise out of the earth and pass but a little way above the surface; but where it is large, as in northern or southern latitudes, they rise up at a greater angle, and pass into the distant realms of space, from whence they return again to the earth in the opposite magnetic hemisphere; thus investing the globe with a system of forces like that about an ordinary magnet, which wherever it passes through the atmosphere is subject to the changing action of its magnetic oxygen. There is every reason to believe that these lines are *held* in the earth, out of which they arise and by which they are produced, just as the lines which originate in a magnet are held by it, though not in the same degree; and that any disturbance from above affecting them will cause a greater change in their place and direction in the atmosphere and space above, than in the earth beneath.

The system of lines of magnetic force around a magnet or the earth is related by a lateral tension of the whole, analogous in some degree to the lateral tension of lines of static electrical force; both the one and the other being easily made manifest by experiment. The disturbance of the tension in one part is accompanied instantly by a disturbance of the tension in every other part; for as the sum of the external powers of a system, unaltered at its origin, is definite and cannot be changed; so any alteration either of tensity or direction amongst the lines of force at one place, must be accompanied by a corresponding change at every other. So if a mass of soft iron on the east side of a magnet causes a concentration of the lines of force from the magnet on that side, a corresponding expansion or opening out

of the lines on the west side must be and is at the same time produced; or if the sun, on rising in the east, renders all the oxygen of the air on that side of the globe less magnetic and less able therefore to favor the transition of the lines of terrestrial force there, a greater number of them will be determined through the western region; and even though the lines of force may be doubted by some as having a separate existence such as that above assumed, still no error as to the effects on magnetic needles would in that case be introduced, for they by experiment would be and are the same.

The power of a magnetic body as iron or oxygen to favor the transmission of lines of force through it more than other bodies not magnetic, may be expressed by the term conduction. Different bodies, as iron, nickel, oxygen, conduct in various degrees, and not only that, but the same body as iron or oxygen conducts in different degrees at different temperatures. When space traversed by uniform lines of magnetic force is occupied by a uniform body as air, the disposition of the lines is not altered; but if a better conducting substance than the air is introduced, so as to occupy part of the space, the lines are concentrated in it, and drawn from other parts as shown by P P, in the figure, or if a



worse conducting substance is introduced, the lines are opened out as at D D. In both cases the lines of force are inflected, and a small magnetic needle standing in them at the inflected part would have its direction changed accordingly. Experimental illustrations of these changes in direction are given in Mr. Faraday's paper in the Philosophical Transactions for 1851, Part I, Par. 2843, &c.

Now this by the hypothesis is assumed to take place in the atmosphere. Supposing it all at mean temperature, the lines of force would have the direction determined by the arrangement of the power within the earth. Then the sun's presence in the east would make all the atmosphere in that region a worse conductor, and cause it to assume the character of D; and as the sun came up to and passed over the meridian and away to the west, the atmosphere under his influence would bring up changes in direction like those shown in either D or D; it would therefore manifestly set a needle in a given latitude in opposite directions as it passed by; and as evidently set two needles in north and south latitudes in opposite directions at the same moment of

time. As the night came on and a temperature lower than the mean came up from the east and passed over, the lines of force would be inflected as in P or P, and a reverse variation of the needle to that which occurred before would now take place.

The natural effects of variation must be produced consequent upon the magnetic nature of oxygen and its daily variations of temperature is manifest; but whether they cause the observed variations, or are competent to do so, is a question that can only be decided after very careful enquiry. Observations are now made on the surface of the earth with extreme care, in many places, and these are collated, and the average or mean result, as to direction and intensity of the earth's force, ascertained for every hour and season; and also many remarkable, anomalous, and extra results evolved. A theory of the causes of any or all of these variations may be examined first by the *direction* which the varying needle does or ought to assume, and then by the *amount* of the variation. The hypothesis now brought forward has been compared by the mean daily variation for all the months in the year at north and south stations, as Toronto and Hobarton, and at many others near to and far from the equator, and agrees in direction with the results observed far beyond what the author anticipated. Thus the paths described by the upper ends of free needles in the north and south hemispheres should be closed curves, with the motion in opposite and certain directions, and so they are:—the curves described by needles in north and south latitudes should be larger in summer and smaller in winter, and so they are:—a night or cold action should grow up in the winter months, and such is the case:—the northern hemisphere ought to have a certain predominance over the southern, because of its superior temperature, and that is so:—the disposition of land and water ought to have an influence, and there is one in the right direction:—so that in the first statement and examination of the hypothesis it appears to be remarkably supported by the facts. All these coincidences are particularly examined into and stated in the Philosophical Transactions already referred to. The next step will be to ascertain what is the amount of change in the conducting power of the air for given changes of temperature, and then to apply that in the endeavor to ascertain whether the amount of change to be expected is (as well as the direction) accordant with that which really occurs.

ART. XI.—*On Eupyrchroite of Crown Point, New York;* by CHARLES T. JACKSON, M.D., Assayer to the State of Massachusetts, &c.

THE specimens of Eupyrchroite which I have analyzed were sent to me by Mr. C. F. Hammond of Crown Point, and he writes to me, that one hundred tons of the mineral have been taken from the mine, and it is understood it is to be employed in the preparation of phosphates for agricultural use. This enterprise has followed the movement which Mr. Alger has made at my suggestion, in working the mine of phosphate of lime in Hurdstown, New Jersey, and I hope it will awaken the attention of mineralogists and geologists to other neglected or overlooked deposits of this valuable mineral, so desirable as a fertilizer, and so important as a constituent of the vegetable products used for food.

When the mode of managing this manure is generally known, there will be a demand for it that all our present known localities will not be able to supply, and therefore, every new discovery of any extensive deposit of it, will be hailed with pleasure.

I learn that measures have been taken to export this mineral to England, where it is most highly valued for agricultural use, particularly in the preparation of the land for the growth of hops. It is also extremely valuable in the preparation of the soil for other crops, all of which contain phosphates in considerable proportions. It appears that the exhaustion of wheat lands by incessant cropping, without adequately replenishing the soil by manures, is owing to the removal of phosphates from the soil. Our farmers should therefore look into this matter, and remedy the evil that an early want of attention to the chemical principles of agriculture has led them into. It is hardly necessary for me to say that burned or ground bones may be used for the same purpose as the mineral I am about to describe; nor will it be necessary to enter upon the discussion of the question as to the indispensable necessity of the existence of phosphates in food, which is to form flesh, blood and bones, for most men know that they have seven pounds of phosphate of lime in their bones, and nearly as much of other phosphates in the soft parts of their bodies. It is also known that the ashes of all cereal grains contain almost fifty per cent. of phosphoric acid, united with lime, potash, soda and magnesia, and that plants derive these phosphates from the soil, which contains generally but a very minute proportion rarely amounting to three-tenths per cent.

Description and Analysis.

This mineral was first described by Prof. E. Emmons in his Report on the Geology of New York, and was analyzed by Prof. Lewis C. Beck and published in his Report on the Mineralogy

of New York, p. 240; but his specimens differ somewhat from mine in their physical characters. It was named Eupyrchroite by Prof. Emmons in allusion to the beautiful emerald green light, which it gives out when thrown on heated iron, its phosphorescence being nearly equal to that of the chlorophane fluor spar of Connecticut.

The Eupyrchroite phosphorite occurs in botryoidal concretions, having a fibrous structure, and an ash-gray or bluish gray color, the concretions being made up of successive layers of different shades of color. Their surface is frequently covered with a delicate film of iron pyrites which scales off readily when scraped with the knife. Its Sp. Gr. is 3·053. Hardness 4½. Before the blowpipe phosphoresces with a green light at first, then gives the intense brightness characteristic of lime salts. It glazes on the surface at a high temperature, but does not melt. In the glass tube it gives out water, which is acid, and corrodes the glass. When thrown in powder on metal, heated nearly to redness, it exhibits a brilliant emerald green phosphorescence. Larger fragments decripitate strongly.

During its solution in chlorohydric or nitric acid, it effervesces slightly, carbonic acid gas escaping. The quantity of this gas was accurately determined by the proper apparatus. In preparing the mineral for proportional analysis, each fragment was carefully examined with a lens, to ascertain that it was free from accidental admixture with other minerals. It was reduced to impalpable powder by levigation, and dried at 212° F., and weighed while still warm. A sample of the mineral in coarse powder was used in the determination of the water contained in it. In the other steps of the analysis the methods as given by Rose were pursued, and the following results were obtained.

Lime,	47·230
Phosphoric acid,	45·710
Carbonic acid,	1·218
Lime,	1·554
Chlorine,	0·130
Calcium,	0·204
Fluorine,	0·599
Calcium,	0·855
Protoxyd of iron,	2·000
Water,	0·500
	100·000

The fluorine as usual was expelled, and thus determined by difference, in the re-formation of phosphate of lime, after decomposition of the precipitated mixed phosphate of lime and fluorid of calcium, and its equivalent of calcium was deducted from the lime obtained as a sulphate of lime.

ART. XII.—*On the Recent Condition of Kilauea;* by Rev. C. S. LYMAN, including a letter from Rev. T. COAN, Missionary at Hilo, Hawaii.

IN an article on "Volcanic Eruptions on Hawaii," published in the ninth volume of this Journal, (May, 1850,) the geologist of the U. S. Exploring Expedition* has given a description of the topography of this remarkable volcano, together with some notices of its various eruptions since it began to be visited by foreigners. To this article the reader is referred for a general description of the situation and character of the crater of Kilauea, illustrated by a plan and section.

The writer of these remarks spent several days at the volcano in July and August, 1846—some six weeks elapsing between the two visits.

A letter has just been received from the Rev. Mr. Coan, the enterprising American missionary at Hilo, Hawaii, whose name has been so often mentioned in connection with this volcano, sketching briefly the history of Kilauea since he and the writer visited it together in 1846. The volcano lying within the limits of Mr. Coan's missionary field, (though forty miles from Hilo,) he often has occasion to pass it in his tours among his people, and thus has become more familiar, probably, with its various changes and aspects for the last fifteen years than any other individual.

Before giving Mr. Coan's letter, it may not be improper to remark briefly on the appearance of the crater at the time of the writer's visits in 1846.

At that time the volcano was represented by Mr. Coan as being in one of its more quiet moods. Indeed, the first view obtained of it on our arrival was so little attractive as almost to produce a feeling of disappointment. The less curious class of visitors sometimes experience this feeling so keenly that they turn on their heel at once and refuse to descend into the crater, fully convinced that they have been deceived by extravagant descriptions, and that nothing is to be seen that will repay them for the trouble. On reaching the brink of the pit, instead of loud detonations and billows of fire, the ear heard nothing save the murmuring of the strong northeast wind as it rushed over the precipice, and the eye saw nothing save a broad, deep, enclosed valley—an apparently sunken tract of the earth's surface—with a black level bottom, strikingly resembling an area of burnt prairie land, from the distant extremity of which were lazily rolling up a few clouds of smoke and vapor, as if the prairie-fire were not yet wholly extinguished.

* See also Rep. on Geol. Expl. Exp., Chap. III.

At night, however, that part of the crater from which the vapors had been seen rising was lit up with what seemed a glowing line of fire. This was the part of the volcano that has generally been called the "Great lake." Save at this point, the volcanic fires were nowhere visible from the upper bank, and only in a few other places were there seen indications of their existence in the jets of steam that were issuing from crevices in the lava. These steam jets, on further examination, were found to exist even out of the crater on the upper bank, in the vicinity of the huts in which visitors find temporary lodgings.

The northern sulphur banks we found to be essentially in the same condition as described by previous observers—lying under a bluff wall of rocky lava from which they are separated by a crevice or chasm, out of which constantly issue steam and sulphureous gases, depositing on the rocks, and even on the branches of certain species of vegetation, beautiful incrustations of sulphur and other substances.

Our place of descent into the crater was the usual one over the broken declivity at the northeastern extremity. On reaching the bottom, we found it difficult, at first, to identify any thing answering to the "Black ledge" spoken of in the narrative of the Exploring Expedition, and by most previous observers. In 1840 the crater, as described by Capt. Wilkes, and by Mr. Dana in the article already referred to, consisted of a sort of pit within a pit—a broad depression in the earth's surface, first by an almost perpendicular wall 650 feet in depth to the Black ledge, and then—leaving the ledge or terrace one or two thousand feet in width all around the crater—by a second abrupt descent of 350 feet or more to the general level of the bottom. In this lower area in 1840, were various pools of fluid lava, the principal one, known as the Great lake, lying towards the southwestern extremity, and measuring at that time 1000 feet by 1500 in diameter.

The terrace or Black ledge thus described we found almost obliterated, the whole interior of the pit having been filled up nearly to a level with it, and in some places from fifty to more than one hundred feet above it. By measuring a base line on the ledge and taking angles with a quadrant, the height of the northwestern wall of the crater above the terrace was computed to be 680 feet, which agrees nearly with the measurement of the Exploring Expedition, and shows that this part of the floor has not been elevated since 1840. Previous to the great eruption in that year, however, there is good evidence that the entire area of the crater, including the former Black ledge, had been repeatedly overflowed, and thus the ledge of the Exploring Expedition, (and which has remained unaltered to the present time,) placed at an elevation of many feet, (some observers estimate it at two hundred or more,) above the Black ledge of Douglass and the earlier visitors.

At the interior margin of what has been described as the Black ledge, especially on the northeast and east, our attention was particularly attracted by a continuous ridge more than a mile in length, consisting of angular blocks of compact lava, resembling the debris at the foot of a range of trap or basalt. This ridge rose on its outer or eastern face often to the height of fifty or one hundred feet, especially towards the south where it approached the Great lake; and generally it left a space, or "canal," as it has been called, between it and the ledge several rods in width, and in some places forty or fifty feet in depth. This was apparently what had once constituted a *talus*, or accumulation of debris on the floor of the crater at the foot of the nearly perpendicular precipice of the Black ledge, at a time when the floor was three or four hundred feet below its level at the date of our visit. That floor, with its margin of debris having been subsequently elevated, partly by upheaving forces from beneath, and partly by successive overflowings from the Great lake and other active vents formerly existing, at length rose higher than the precipice at the foot of which it was accumulated, and presented to view the rocky ridge we have been describing—a phenomenon that seems inexplicable on any other hypothesis than that of the bodily upheaving of the inner floor of the crater. The fact of such elevation is further evident from the appearance of these ridges on their inner or western slope. This side was broken and precipitous like the other, but of a much inferior altitude. Indeed, the altitude gradually diminished towards the southern portion of the ridge, till in the vicinity of the Great lake, instead of a ridge it became simply a precipitous bluff facing the east, from the top of which spread out an uneven plateau occupying the whole central portion of the crater north of the lake, and elevated more than a hundred feet above the Black ledge. This wall was too steep and high to be scaled by our party, but the plateau just mentioned was subsequently visited by the writer, and at its southeastern limit so precipitous was the descent, that stones hurled from the hand cleared the foot of the bluff, and occupied nearly three seconds in falling—which would give for the perpendicular elevation the amount that has just been stated.

Thus the entire portion of the crater within the black ledge appears to have been filled up, or elevated, on an average more than 400 feet between 1840 and 1846; and from the testimony of subsequent observers, it would seem that the process of elevation, especially in the neighborhood of the Great lake, has been going on with greater or less efficiency to the present time.

The "canal" spoken of, or the space between the inner margin of the old Black ledge, and the outer margin of the central portion of the crater, was so named from the fact that formerly, when it was 200 feet deep or more, molten lava had been ob-

served by Mr. Coan flowing into and along it from the great lake. On one occasion, indeed, the glowing stream was seen by him to plunge in a fiery cataract down a precipice fifty feet in height—presenting a sublime spectacle. By these successive overflows this space had, in 1846, become nearly filled up, and in many places the former "canal" was entirely obliterated.

The Great lake in 1846 was by approximate measurements computed to be about 2400 feet in diameter from N.E. to S.W., and 2000 in the transverse direction. Its surface was nearly on a level with the Black ledge and with that portion of the floor of the crater between it and the ledge. It was surrounded on all sides except the northern or northeastern, by a rim or embankment of lava from ten to twenty feet in height, built up apparently by repeated partial overflowings and the marginal deposit of clots and jets of lava thrown up by incessant ebullition—somewhat after the manner of the ridge of ice congealed around a fountain, or accumulated along the margin of a river. On the N.E. the lake was bounded by a high broken and almost inaccessible tract of lava, rising at length into the elevated plateau before described. When visited by the Exploring Expedition in 1840, the surface of this lake was between three and four hundred feet below the Black ledge, and measured only 1000 by 1500 feet in diameter. Consequently in six years it had not only increased in size, but it had actually risen in height as much as it had been previously depressed by the outdraining of lavas in the eruption of 1840. This gradual rising of the solid embankment of the lake contemporaneously with the lake itself, together with the filling up of the whole interior of the crater, is doubtless to be attributed to the combined effect of repeated overflowings, together with the upheaving agency of subterranean forces.

The surface of the lake was constantly in a state of gentle ebullition, yet in consequence of the rapid cooling, becoming covered repeatedly with a thin crust, which crust was again constantly breaking up, and redissolving in the molten mass. The clots or jets of gory lava thrown up by the escaping gases often ascended from five to fifteen feet, and there was a general motion of the surface of the lake slowly towards the southwest. This motion was observed first on the western side, and afterwards at several different points on the eastern. A large stick of wood thrown on the lake, at a point where the ebullition produced a sort of eddy or rolling in of the lava, was immediately taken out of sight, but the next instant a more violent ebullition, together with a sudden outburst of flame and smoke told how almost instantaneously the stick had been transformed into charcoal.

The surface of the fluid lava was some ten or fifteen feet below the top of the embankment, and inaccessible by any means at our command for dipping it up. The spectator, however,

could stand on the very brink of the enclosing rim within a dozen feet of the contents of the great cauldron, with only a handkerchief or hat held before the face to guard against the effects of the intense heat. The non-conducting power of lava in respect to caloric was strikingly shown by an incident that occurred during our visit. A Panama hat was accidently blown from its wearers head, and deposited by the wind on a thin crust of lava that had just stiffened and turned black on the surface of the lake. Though all expected to see it instantly in flames, it was slow in becoming charred, and five or six minutes elapsed before it finally took fire and disappeared. In 1846 the only lake or pool of molten lava in all the crater was the large one we have been describing; all the others noticed by previous observers had become extinct. Near the center of the crater the writer visited a depression of great extent, and perhaps a hundred feet in depth, very irregular in surface and outline, and full of fissures and chasms from which volumes of steam and vapor were issuing. This may have been the seat of one of the large active centers of liquefaction described by former visitors. Not far from this place, at the bottom of a chasm forty or fifty feet deep, lava of a cherry red hue was discovered, and the orifice of the pit was lined with beautiful incrustations of sulphur. A very accessible and interesting point in the crater was about a mile north of the Great lake, where a small cone or dome ten or twelve feet high presented almost exactly the appearance of an artificial furnace or oven. The walls of the dome were scarcely more than a foot thick, and through two openings, the one a foot and the other half a foot in diameter, the interior was revealed of a glowing white heat, and by throwing pieces of lava into these orifices they were seen to fall into the pasty, semi-fluid mass ten or fifteen feet below. This furnace was in full blast at the writers second visit, six weeks after the first.

The exterior walls of the crater seem to the eye at a distance to be nearly perpendicular. But this is far from being the fact, except on the northern and western sides. The writer during the two visits referred to descended into the crater, or emerged from it, at four different points—first at the usual place of descent on the northeast; again by climbing up the slope where lava of the eruption of 1832 flowed down from the very top of the precipice to the bottom at an inclination of not far from 45°—a most hazardous place of exit; next down a gentle slope to a sunken plateau or terrace lying above and back of the sulphur banks on the southeastern side of the crater, and from this terrace by an equally gentle slope to the bottom; and lastly down the easy sandy declivity at the southern extremity of the crater, where the angle of inclination is not over twenty-five or thirty degrees. From numerous positions on the margin and within the crater compass

bearings were taken for the purpose of fixing the topography of the points of principal interest, and from these and other observations were derived the few data mentioned in the present paper.

During the six weeks intervening between the two visits of the writer almost no perceptible change had taken place in any part of the crater, except that the Great lake had apparently risen four or five feet. Two or three months afterwards, the lake overflowed its embankment, and subsequently retired to its former level.

Since 1846, as will be seen from the communication of Mr. Coan, great changes have taken place, and the general aspect and modus operandi of the volcano have undergone various revolutions. The Great lake has ceased to exist as a cauldron of boiling lava. A huge dome surmounted by cones of eruption has been formed over it. The general activity of the volcano has suffered apparently a large diminution, and the crater has become gradually choked up. The latest report from the Islands, of a date subsequent to Mr. Coan's communication, speaks of a new eruption having occurred at Kilauea, but the extent and character of it are not described.

Mr. Coan in his recent letter to the writer, remarks as follows:

Letter of Mr. Coan on Kilauea, dated Hilo, January, 1851.

You recollect the aspect of this unique volcano at the time we visited it in 1846. My next visit to the crater was in July, 1847, in company with Capt. DuPont and several officers of the U. S. ship Cyane. No essential changes had occurred in the bottom of the volcano during this interim, except that the Great lake had filled up, had overflowed a considerable area around its rim, was still full and in an active state.* The boiling of the lava was intense around most of its circumference, and at many points over its surface. Access to the red-rolling fusion was comparatively easy, so that by carefully watching and dodging its fiery jets we could dip up its viscid matter with sticks or ladles. Several gentlemen imbedded coins in the lava while in fusion and kept them as specimens. Silent and successive overflowings took place from time to time during this year, considerably elevating all the area in the vicinity of Halemaumau, or the lake, but not affecting the other and larger portions of the crater. I think it was about the beginning of 1848 that the Great lake was first noticed as crusted over with a thick stratum of lava;

* In a letter dated Dec. 7th, 1846, Mr. Coan says: "Visited the volcano a few days ago." "Found the lake full and active. Dipped up the molten lava with our canes."

and this stratum was soon raised into a dome some 200 or 300 feet high over the whole lake; traversed here and there by rents and fissures, and studded by an occasional cone. Occasionally the visitor or the passing traveller would descry, through these fissures, the glowing of the subterranean fires, and now and then the gory mass would be pressed sluggishly through these chasms, or driven up with more force through the several chimneys, apertures, or orifices of the dome. These eruptions rolled in heavy and irregular streams down the sides of the dome, spreading over its surface or cooling at its base. Thus the dome, as it now exists, has been formed by the compound action of upheaving forces from beneath and of eruptions from its openings, forming successive layers upon its external surface. During most of this year, however, (1848,) an extraordinary *inactivity* prevailed throughout the crater, so that visitors chided the long slumbers of the goddess, and were impatient with her drowsy propensities. During the summer and autumn of this year, when I was at Kilauea, there was no fire to be seen, even in the night. Old Vulcan seemed to have forsaken his furnace, buried his fires and retired to his deep, dark caverns, leaving his awful forge surrounded with smouldering masses of scoria and slag. At the time of my visit in August, the great dome was so elevated as almost to overtop the lower parts of the outer walls of Kilauea and look out upon the surrounding country. No important changes were noticed in the crater from this time until the spring of 1849. In April and May of this year, travellers upon the borders of Kilauea were startled by explosions and detonations from cones on the great dome. A party lodging in the hut on the upper banks were greatly terrified during one whole night, by hissings, bellowings, and sharp and loud detonations, sometimes like the discharge of whole ranks of musketeers, sometimes like field artillery, and sometimes like awful deep toned thunder, roaring, and reverberating around the adamantine walls of the dark cavern. These bellowings were repeated hourly through the night, and were attended by a brilliant column of red-hot lava thrown perpendicularly from an orifice in the apex of the dome, to the height of some fifty or sixty feet. At other times red-hot stones were projected with great force into the air and sent whizzing like fiery meteors through the gloom of night. As the glow of this scene a little abated, a stream of burning lava was disgorged from the orifice of a lateral cone on the ridge of the dome, flaming down to its base and winding along upon the dark substratum like a fiery serpent. Fire was seen through some of the fissures in the dome, and nearly the whole bottom of Kilauea was quivering and crackling with heat; so much so, that travellers feared to descend into any part of the crater.

These reports I have from those who professed to have been eye and ear witneses of the thrilling scenes. Since the time just mentioned no remarkable phenomena have been noticed in the crater. It has been for the most part in a quiescent state, with more or less steam and smoke, and occasionally opening a small red eyelid, or letting loose a few fire flies upon the wings of the night.

During December of 1850 the smoke and steam are said to have much increased; and the occasional throe of an earthquake indicates that all subterranean action has not ceased. Kilauea is evidently assuming more of the manners and habits of the fiery sisterhood. Her exhibitions are becoming periodical, arbitrary, capricious. With the exception that her throne is not a mountain summit, she more and more resembles Etna, Vesuvius and the Andean and Asiatic furnaces.

The sulphur beds remain much as formerly, except, perhaps, that the bank within the crater has less heat and activity, and the one above, or near the hut has a little increase of heat. Most of the sulphur is now obtained at the beds near the hut.

The eruption of 1840 is still hot and steaming at many points along its course, and hundreds of steam holes are still smoking in Puna and parts of Kau.

There is now one cone feebly active at a little distance from the dome in the crater. Those *on* the dome are now inactive.

The eruption in Mokuaweoweo, or the great crater on the summit of Mauna Loa, was first noticed in May, 1849, some little time *after* the extraordinary activity of Kilauea. This eruption never overflowed the crater in which it occurred, but spent all its force within the bowels of that deep chaldron. For two or three weeks it shot up a tall, beautiful and brilliant column of light perpendicularly and to a great height; this column, like that which led Moses and the hosts of Israel, being "a pillar of cloud by day and a pillar of fire by night." At the end of two or three weeks it faded away and disappeared.

The eruption on Mauna Loa immediately succeeded the action in Kilauea. I cannot say they were coincident; though they *may* have been, as the mountain is, as you are aware, often obscured in clouds. Whether or not there were any connection between the two eruptions we cannot determine.

Note by J. D. Dana.—If there was actually a connection in the instance above alluded to, the trifling effects observed may well excite our surprise: for how could so slight agitations be all the result, when the lava stands in Mauna Loa to a height of 10,000 feet above the great open pit of Kilauea on its slopes—10,000 feet higher in one leg of the syphon than in the other,—the crater too at the summit being in eruption at the time? See this Journal, x, 244, 1850, and Proc. Amer. Assoc., Cambridge, 1849, p. 95.

ART. XIII.—*On the causes of the disengagement of Electricity in Plants, and upon Vegeto-terrestrial Currents;* by M. BECQUEREL.*

SINCE the discoveries of Galvani and Volta, the researches on the development of electricity have taken a philosophical direction. It has been the object to discover not only the causes of its disengagement, but also the relations existing between electricity, molecular attraction and chemical affinity. The study of electro-physiological phenomena has also been pursued; and although to a less extent than other departments of this subject, the labors of Nobili, Marianini, Matteucci, du Bois-Reymond and others, show that general physics and physiology may alike profit by researches upon the presence of electricity in the operations of organic life and in the constitution of organized bodies.

The causes of the development of electricity in organized bodies, living or but a short time deprived of life, are physical, chemical and perhaps organic; and in the last case, they pertain to certain vital functions not yet clearly defined.

My object in this memoir is to exhibit the proper mode of investigating the physical and chemical laws operating in the production of electro-physiological phenomena, and also to give the results at which I have arrived in my researches on plants, whose simplicity of structure renders experiment more easy than with animals.

Some preliminary explanations are necessary to render the subject intelligible.

Organized bodies of the animal kingdom consist of osseous, tendinous, membranous, fleshy, &c. parts filled or moistened with liquids which render them more or less perfect conductors of electricity; and those of the vegetable kingdom, of woody fibre, vessels, &c., in which liquids are present with the same result. As the solids alone have no conducting power, the liquids act the principal part in the production of the electric effects observed, although vital action may intervene in some cases. These liquids, when two are in contact, necessarily produce through the resultant reactions sensible electric effects; observable not only with the condenser, by putting one of these liquids in relation with the earth and the other with one of the plates, but also with the multiplier by closing the circuit with two plates of platinum plunged in these liquids.

There may also be chemical reactions and currents without using the plates of platinum, when the solids and liquids are arranged as will be soon explained.

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* Ann. de Chim. et de Phys., xxxi, 40, 1851.

In aiming to ascertain the chemical origin of the currents produced in the interior of an organized body, it should be remembered that if two different liquids, separated by a permeable membrane are put in communication by means of two plates of platinum in connection with a multiplier, the magnetic needle deviates in a direction which indicates that the liquid acting as the acid sets free positive electricity, and that acting as alkali, negative electricity. The intervention of metallic plates is here indispensable to the production of electric currents; but it is unnecessary when certain solid substances, non-conducting and permeable, and liquid conductors, are arranged as follows, as already explained to the Academy.*

If solutions of potash and nitric acid separated by a thin layer of clay are put in communication by means of two plates of platinum, the acid liberates positive electricity as I have just said. If we substitute for the plate a tube having the form of a U, one decimeter in length, filled with moistened clay free from lime, and so prepared that the part which is plunged into the acid should be less and less acid, and that in the alkali less and less alkaline, in order that there may be but a simple chemical reaction, we have then an apparatus by the aid of which, on breaking the tube so as to have two conductors, decompositions may be produced.

Similar arrangements to this are found beyond doubt within organized bodies consisting of solid parts more or less permeable, and liquids which mingle only with difficulty under the operation of life, on account of the tissues.

When public attention was first called to the admirable discoveries of Volta, Dr. Baccomio of Milan† endeavored to construct piles of organic substances of vegetable origin, as Matteucci has for some years done with portions of animal muscle; but no true effects of the action of a pile were obtained. And how did Dr. Baccomio operate? He made a pile out of disks of the root of the beet, five to six centimeters in diameter and disks of walnut of like size, with which he caused a frog to contract, using as an excitor the leaves of Cochlearia. As there was nothing to prove that a similar effect would not have resulted from a single pair, there is no evidence for believing that the whole acted as a pile, especially if we consider the following facts.

M. Donné has obtained currents from animals and vegetables by putting in communication, by means of metallic plates or wires connected with a multiplier, liquids of *different* composition belonging to one and the same body and capable of acting chemically on the surrounding liquids. Having placed a plate of platinum in the mouth which is commonly alkaline, and

* Comptes Rendus, xxiv, 505.

† Ann. de Chim. [2], lxii, 212.

the other upon the skin which secretes an acid, the needle deviated fifteen to twenty or even thirty degrees,—the mucus of the mouth on account of its alkaline nature giving the negative current. M. Donné obtained similar effects by experimenting on the stomach and liver, one secreting an acid and the other an alkali. Analogous effects take place with fruits; on inserting a needle of platinum into the stem end of the fruit and another into the opposite, there is an electric current; in apples and pears the current is from the flower-end to the stem-end, and in peaches, apricots and prunes, the reverse. If the needles are inserted at opposite points, 90° from the ends, (that is in the equatorial plane,) there is no current. The effects obtained were evidently due to the different composition of the liquids. On cutting a prune in two equatorially, and then obtaining the juice from each, and making with it a circuit, the currents were obtained as before, and in the same direction. The cause in such cases is evidently chemical.

Similar results are obtained when experimenting in organized bodies with two metallic conductors, if they are put in contact with two different liquids separated by tissues or permeable membranes. A frog prepared as by Galvani may be used in place of metallic conductors; its contractions indicate the electric effects that are produced immediately when the circuit is formed.

May the effects here manifested take place without the intervention of metallic conductors or the frog? To this, I shall reply soon. I mention here, that whenever two liquids react chemically upon one another, if these liquids do not form part in a closed circuit, there is an immediate recomposition of the two electricities disengaged at the point of contact; but if one of the two liquids is put in communication with the earth, or loses by evaporation the electricity which it possesses, the electricity of the other liquid may be collected with the conductor. Such are the data for studying the questions under consideration in this memoir.

I. *Electric effects produced by the Circulation of Sap.*

In plants, there is an ascending sap and also a cortical sap, the latter differing in composition from the former, and having, according to some physiologists, a descending movement. They are separated by tissues and produce effects like those above mentioned. These effects are the more remarkable from their relation to the composition of the bark and wood. To interpret them, it is necessary briefly to recall what is known upon the nature and distribution of these two varieties of sap.

The stem of a ligneous dicotyledonous plant is formed of two distinct parts, the bark, and the wood properly so called, separated by a liquid substance considered by many physiologists a semi-fluid tissue, called *cambium*, which is the principal element of

vegetable organization. The bark consists independently of the parenchyma, of epidermis, laticiferous vessels and cortical fibres. The wood is formed of medullary rays, of woody fibre, and pith. The bark like the wood contains a cellular and a fibrous part but in inverse position. The parenchyma which is analogous to the pith occupies the exterior of the bark, whilst the pith is at the centre. This inverse position corresponds, as will be seen, to inverse electric effects.

As each stem or branch is composed of an uninterrupted series of concentric heterogeneous layers, their successive contacts ought to give rise to electric currents proceeding from the unlike character of the liquids moistening these layers. These effects are rendered sensible—1, by the aid of platinum needles introduced into two contiguous or more or less distant layers, reacting upon the neighboring layers; 2, by collecting with a condenser the electricity carried off from the plant by the vapor of water exhaled by the leaves and by the oxygen proceeding from the decomposition of carbonic acid under solar influence; 3, by using platinum needles in order to ascertain the simultaneous electric states of the plant and the earth.

The moisture of the earth enters the roots by their extremity through endosmosis and capillarity, passes into the cellules situated above, and reaches the stem where the ascending movement is continued: it dissolves some portions of substances in its course, increases in density, and constitutes then what is called sap. The ascent of the sap is due not only to endosmosis and capillarity, but also to the buds which by their growth draw up the stem and branches the material necessary for their development. The buds form leaves, which by affording evaporation, aid in the production of the ascending movement and are a means consequently of manifesting electric effects.

We know not with exactness the different organs passed through by the sap in its evolution. We can say only that in spring it fills the cellules, the fibres, vessels, &c., and occupies almost entirely the woody substance. The ascending sap, reaching the young branches, passes to the surface of the bark in the parenchyma as well as to the leaves; and when once spread in the green part, it is in direct connection with the atmospheric air, separated from it only by a thin membrane through which respiration is going on. The sap, which is thus intimately modified, becomes less aqueous through evaporation of a part of its water. Carbonic acid gas is decomposed, carbon is assimilated and oxygen exhaled. The color of the leaves and young bark shows that considerable changes are going on in the sap. Does this sap, newly elaborated, redescend through the bark, depositing along its passage material for the formation of tissues? Some physiologists still doubt on this point. But the experiments of

Biot tend to prove the circular movement of the sap. On examining the optical properties of the ascending and parenchymatous sap of the maple, he observed that the first caused the plane of polarization to turn to the right and the second to the left, whilst the two saps of the birch acted the reverse. These experiments which according to Biot establish a reciprocal dependence between the two saps, are supposed to demonstrate their circulating movement. It is certain at least that the parenchymatous sap differs from the ascending sap.

The anatomical and physiological details just given were required for interpreting certain electrical effects produced in the different phases of the movement of the sap, effects of interest to meteorology as well as to vegetable physiology.

The following are the experiments. Suppose now a stem of a young poplar (when in sap) has been laid open by a transverse section, so as to show distinctly all the concentric layers of which it consists. If the extremities of two platinum needles without polarity, covered or not with a layer of distilled water and in connection with a multiplier, be introduced simultaneously, the one in the pith and the other in one of the layers of the wood or cortical system, the needle deviates 5, 10, 15 degrees or even more, according to the sensibility of the apparatus, the sappy state of the plant, and the nature of the envelop in which the second needle is placed. The direction of the deviation, which is invariable, indicates that the pith furnishes positive electricity to the needle in contact with it, and the outer envelop negative electricity to the other needle; there is then a current from the exterior to the interior.

The magnetic needle after some oscillations takes an equilibrium which is not fixed, the deviation diminishing by degrees without ever reaching zero. This diminution in the intensity of the current is due to the polarity acquired by the platinum needles, which produces a current inverse to the former and destroys its action. The primitive current is the more intense, other things equal, the nearer the insertion of the outer needle is to the epidermis and consequently to the green part of the parenchyma.

On drawing out the first needle from the pith, and inserting it at different points, approximating towards the surface, the currents are similar in direction but of diminishing intensity; and this goes on until the needle is placed in the *cambium* between the wood and the bark, when the current changes in direction and becomes more intense.

On raising a piece of bark, from which the epidermis is easily removed, and applying a plate of platinum to each surface, both being connected with a multiplier, effects of great intensity are obtained. With the bark of alder in full sap, the deviations are

sometimes 90 degrees, and the needle may even whirl round. It is hence evident that *the bark forms a voltaic couple*, the outer surface or parenchyma being the positive side and the inner covered with the cambium the negative. The action soon ceases when the bark is removed from the branch. This is shown by taking a piece of the bark of a young branch of alder, removing the epidermis and putting it between two plates of platinum and the whole under a pressure of 2 kilograms between two pieces of wood; a current is immediately produced; but on repeating the trials at short intervals, being careful to depolarize the platinum plates each time, the effects diminish rapidly, although the surfaces may be moistened with distilled water,—and sometimes they are not sensible after half an hour. These electric properties diminish much more rapidly than in the muscles of cold-blooded animals in which they remain several hours after death.

When the bark is not separated from the branch, these properties continue for several days, proving that their disappearance should be attributed to chemical changes which take place in the sap through contact with the air.

The bark is in reality, therefore, a voltaic couple, which loses rapidly its electric property when detached from the wood and left exposed to the air. It follows, that in the reaction upon the sap of the layer of air that adheres to the surface of the platinum, there ought to be somewhat analogous effects, as regards intensity, to those which take place by contact with the atmosphere. The layer of hygrometric moisture adhering to the surface of the platinum has no influence, since the effects are the same if the needles have been previously heated to redness.

In recapitulation,—we see, that from the pith to the cambium, the ligneous layers are less and less positive with reference to the pith, while from the cambium to the epidermis, the cortical beds and parenchyma are more and more positive, or at least comport themselves thus. In the production of the derived currents, this inversion in the electric effects corresponds with the position of the cellular tissue in the bark and in the wood; in the bark it is external, in the wood internal, and in each case it is positive.

Where then, do the electric properties of the bark reside? Is it in the different layers which compose the cortical system, or only in the epidermis and cambium? The following experiments, if not completely settling this question, tend to its elucidation.

If we take a branch of alder in full sap, and make a transverse section, then insert one of the needles between the bark and the wood and the other into the parenchyma after removing the epidermis, the needle deviates a certain number of degrees, say 20°. If we now withdraw the second needle which was placed in the periphery, remove the green layer with an ivory knife

and put the needle in place again upon the denuded surface, there is sensibly the same deviation. If another layer be removed, there is still by a similar trial a deviation in the same direction but a little less strong, or about 15 degrees. On continuing the removal of the layers and making successive trials, the electric effects take place in the same direction and do not cease until only the cambium is left. All the parenchyma cortical layers thus have a like effect; and does it therefore follow that the layers united form a voltaic pile? Certainly not: the experiments thus far made do not authorize this conclusion.

However it may be, the cause which makes the bark a voltaic couple and perhaps a pile, by the juxtaposition of the concentric heterogeneous beds of which it consists, appears to be purely chemical. In fact, the ligneous system is penetrated by the ascending sap rich in oxygen, while the liquid in the cortical tissue, on traversing the green parts, is continually losing a portion of this element by contact with the air. These two saps, by reacting upon one another, through the medium of the intervening tissues, necessarily cause electric effects; the ascending sap, which is most oxygenated should act as an acid with regard to the other, and develop positive electricity, while the descending sap should disengage negative electricity. The inversion in the bark and wood depending on the position of the cellular tissue, is to be attributed to the nature of the liquids they contain.

The electricities disengaged when one of the needles is inserted in the pith and the other in the parenchyma, have, I repeat it, a chemical origin; for if the needles are withdrawn and while still covered with the sap are put into distilled water, the same effects nearly, as to intensity, are obtained, effects which can be attributed only to the reaction, upon the water, of the sap adhering to the surface of the needles.

In these experiments, for inserting the needles into the stem, especially the woody part, I make small holes with a steel awl covered with a thick layer of gold, so that no trace of oxydizable metal can be introduced to occasion secondary electric effects.

In herbaceous plants, like Cacti, Euphorbiæ, &c., consisting almost wholly of parenchyma, it is difficult to detect the electric effects which are so distinct with stems provided with bark.

As bearing upon this subject, I mention the following experiments which will show the rapidity with which the air reacts upon the sap in the green parts and modifies its composition.

The ascending sap being more oxygenated than the parenchyma sap, called the descending, ought to give out, by its action upon the latter, positive electricity as before observed. If we insert transversely under the epidermis, into the parenchyma, the two platinum needles, one centimetre apart, there will be no

effect, if the insertion of the two needles is simultaneous and they are not polar. But on withdrawing one needle and inserting it again in the same place, there is at once a current causing a deviation of 40 degrees, and the direction shows that the needle restored gives negative electricity. On removing and replacing the other one, the effect is reverse, and this one now gives negative electricity. This succeeds well if the wood is in sap and has been separated but a short time from the trunk.

In this case, the effect is similar to certain facts mentioned in my earlier work on electro-chemistry. When two plates of platinum in connection with a multiplier, are put into a solution, recently prepared, of protonitrate of iron, on withdrawing one of the needles and inserting it again some minutes after, there is a current whose direction shows that the plate replaced gives positive electricity. This effect proceeds simply from the fact that the solution of the protonitrate, and the part of this solution which is on the platinum plate while exposed to the air, are not alike in composition: the portion adhering to the plate has passed, during the exposure to the air, to a higher state of oxydation, and comports therefore like an acid with reference to the solution in the vessel. The steps in the process are easily explained. When nitric acid reacts on iron, deutoxyd of nitrogen and nitrous gas are disengaged, and protonitrate and some deutonitrate of iron are formed; when the solution is exposed to the air, the deutoxyd becomes nitrous acid and the protonitrate deutonitrate. These transformations which take place slowly in the mass of the solution, are effected very promptly in the layer that adheres to the surface of the platinum. On becoming rapidly saturated with oxygen, the solution reacts upon the solution in the vessel and produces electric effects like those from the action of an acid on an alkali, or from two substances reacting as such. The recently prepared protonitrate is required for these vessels, because of the change to deutonitrate which takes place in the protonitrate after a while on exposure.

If in the experiment with the sap the effects are the reverse of those with the protonitrate, it is owing to this;—that the sap of the parenchyma loses oxygen on exposure instead of gaining it.

These facts demonstrate that a very slight difference of chemical composition in two liquids of a plant, separated by a permeable membrane, is sufficient to afford electric effects in the manner explained, and these effects vary with changes experienced through the surrounding air or medium.

These effects should therefore be taken into consideration in experimenting upon the causes which produce electric currents in organized bodies, when one of the liquids is momentarily in contact with the air.

The electric effects produced between the sap of leaves and the same sap exposed a moment to contact with the air, may be shown by piling up thirty leaves or so and compressing them strongly, then inserting two needles, one on each side; on taking out one and again restoring it to its place after some instants, it gives negative electricity. This is due to the change in the sap of the parenchyma on the needle that had been exposed.

The intensity of the current depends on the quantity and the composition of the liquid in the leaves. Those of ivy produce a deviation of twenty to thirty degrees; those of the poplar of Italy a little less or more strong, according as old or young leaves are used. Complex effects sometimes result from modifications more or less profound which the sap undergoes in contact with the air, and from the facility with which the sap, on the exposed needle, mixes with the surrounding medium, gaseous or liquid.

It is possible therefore to compare leaves of different kinds in this respect, such as elder and walnut. Twenty leaves of each kind, in two piles, are put in contact by one of their surfaces and compressed. A needle of platinum is inserted in each surface; one of these needles is withdrawn and after some instants replaced. The direction of the deviation shows that the replaced needle gives negative electricity. The amplitude of the deviation depends on the nature of the leaf, as the following results from the walnut and elder show.

The needle removed and again replaced in the elder gave for deviation, on the first impulsion, for three trials, 13°, 13°, 11°, and for three alternate trials with the walnut, 24°, 22°, 24°.

These results show that the sap of the walnut undergoes a more rapid change by contact with the air than that of the elder, the current being nearly double in intensity.

Leaves of poplar combined with those of walnut give results still more marked. The leaves of poplar with regard to those of ivy, afford the relation of thirty to twenty.

We can draw no conclusion from these results whilst we are ignorant of the chemical composition of the different saps: we only know that all do not undergo the same alteration in equal times. Such piles, made of series of leaves of different species, may yet serve to educe facts of importance illustrating some points in vegetable physiology. If two such series of leaves are put in contact, and, before pressure, a plate of platinum connected with a multiplier is applied to each free face, we obtain the following results, with walnut, elder, linden, and orange, arranged in couples:—

		Kind of electricity.	Angle of deviation.
1.	Leaves of walnut, . .	—	35°
	" elder, . .	+	
2.	Leaves of linden, . .	+	20°
	" walnut, . .	—	

		Kind of electricity.	Angle of deviation.
3.	Leaves of linden, . .	+	30°
	" elder, . .	—	
4.	Leaves of orange, . .	+	10°
	" linden, . .	—	
5.	Leaves of orange, . .	+	50°
	" walnut, . .	—	

In the preceding pages I have treated of the effects obtained with a transverse section of a stem; it remains to speak of the electric effects observed in a longitudinal section. Let *a* and *b* be two points in the green part of the parenchyma of a stem at different distances from the ground and several decimeters apart, *a* being the upper and *b* the lower. On introducing transversely into the parenchyma at each of these points one of the platinum needles, there is immediately apparent an electric current, the direction of which evinces that the needle at *b* gives negative electricity, and that at *a* positive. Hence the parenchyma sap at points thus distant has not the same composition: at the lower point *b*, as it contains less oxygen than at *a*, since it loses more and more oxygen in passing along the green part of the parenchyma, it ought to disengage negative electricity.

A current is also obtained on establishing a connection between the cambium and the leaves, which may be effected, by placing one needle between the bark and the wood, and the other in a mass of superimposed leaves all being a part of the plant. On closing the circuit, a current at once appears going from the interior to the exterior, as in the case when the needle which is here in the leaves is placed in the parenchyma while the other is in the cambium; the result corresponds to the nature of the sap which circulates in the leaves and parenchyma. We give beyond, the consequences from the facts that have been presented.

II. *On the Electric state of the earth relatively to that of Plants.*

As the earth is in direct and permanent communication with plants by means of the roots, it ought to participate in the electric state resulting from the different elaborations taking place in their tissues. This question bears upon the electric state of the atmosphere, and nothing should be omitted which can serve to elucidate it.

It is known that the earth is in a constant state of negative electricity, whilst the air, when calm and without clouds, contains an excess of positive electricity whose intensity goes on increasing as we ascend above the surface of the earth. The earth and atmosphere are therefore ordinarily in two contrary electric states. These states change during storms or when clouds appear; for

these are sometimes positive, and sometimes negative. What are the causes which operate in the production of the electric effects of the earth and atmosphere? We cannot give a reply wholly satisfactory to this question, although we know that chemical changes going on upon the earth's surface must be powerful causes.

De Saussure and several other physicists have endeavored to find evidence of the disengagement of electricity during the evaporation of water. But as they have not taken into account the alteration which the vessels experience in the process, the results were evidently unsatisfactory. M. Pouillet undertook the experiments anew, endeavoring to get rid of the causes which complicate the problem. He sought to prove that evaporation and chemical action in vegetables were the two great sources of atmospheric electricity. I will mention his results, that they may be compared with the facts presented in this memoir.

If a little water is thrown into a platinum crucible heated to a white heat it takes the spheroidal state and evaporates slowly, and on cooling to a certain temperature suddenly passes to a state of vapor. By means of the condenser no disturbance of electric forces was perceived, either during the slow evaporation, or the rapid dispersion of the water.

With acetic acid, sulphuric acid, very pure nitric acid, in place of water, there was no disengagement of electricity perceived; but the result was different when the water held in solution a salt or some substance that is a conductor of electricity. According to M. Pouillet, electricity was produced with a solution of strontian during slow evaporation; and when the water was put in vibration, the amount was quite considerable. The vessel became positively electric and the vapor negative. Hence, at the instant when a separation takes place between the molecules of water and those of strontian, electricity is given out; the strontian retains the positive, whilst the water on evaporating carries with it the negative. The earths and alkalies act in the same manner as strontian.

On experimenting with water containing ammonia, there was an abundant discharge of electricity, but with reverse electric products; the vessel becomes negative, and the water which vaporizes with the ammonia positive,—indicating that the latter, in passing off, carries with it an excess of positive electricity.

If the water holds in solution 1–100 of sulphuric acid or even less, there is a discharge of electricity and the vessel is negative.

With saline solutions, electricity was equally given out; the vessel was always negative whether the salts were neutral, subsalts, or acid. The vapor of water was constantly positive.

I should here state that several physicists who have repeated the experiments of M. Pouillet with saline solutions, a solution

of common salt for example, have obtained distinct effects (operating by throwing some drops of the solution on a plate of platinum raised to a white heat,) only at the instant when decrepitation began, an effect announcing the volatilization of the last portion of the water.

As to the electric effects produced in vegetation, M. Pouillet experimented as follows. Having placed upon a varnished wooden table twelve glass capsules covered with varnish and forming two ranges, he filled them with earth and connected them together by means of platinum wire passing it from the interior of one to the interior of another, and so on; he then put the system in communication with the superior plate of a condenser whilst the inferior plate was in connection with the soil. Different grains were successively sown in the earth of the capsules. During the first two days the grains swelled and the germs came out of the envelop. The condenser gave no signs of electricity. When the germs had risen above the soil, on separating the two plates of the condenser, the two strips of gold-leaf diverged, and evinced negative electricity. M. Pouillet thence concluded that during the action of the oxygen of the air on the amylaceous substance of the cotyledons, the gases which are disengaged carry with them some positive electricity, and leave in the young plant and consequently in the earth an excess of negative electricity. Some hours were required to charge anew the condenser. During the night and morning, the same results were obtained, showing that light had no influence, which is natural since light does not intervene in the first acts of vegetable life. The experiments were made with wheat, grains of garden cress, and gillyflower, and the same results were obtained for ten or twelve days.

M. Pouillet has also observed that when the growth of a plant has been in progress three or four days, the condenser is charged if by connection for a second only;—an effect due, according to him to this, that the earth of the capsules becomes on drying, an imperfect conductor and so retains for some instants a portion of disengaged electricity which serves to charge the condenser at intervals.

In all probability, the effect observed by M. Pouillet should be attributed to the action of the oxygen of the air upon the carbon of the amylaceous material of the grain, which is thereby changed into sugar destined for the nutriment of the embryo during the first periods of growth.

The electric effects observed by M. Pouillet, in this first period, accord with the ordinary electrical states of the earth and atmosphere: but are they produced also in the subsequent stages of vegetation? I think not, judging from facts to which I shall soon refer.

The different electrical states of the earth and air have been attributed also to the gradual decrease of terrestrial heat from the lower parts of the solid crust, even to the highest limits of the atmosphere. I have been the first to bring forward this opinion; but as yet there is no fact that proves it.

I proceed now to the concomitant electric effects obtained from the earth and plants, after the plant is grown, or has made considerable progress towards maturity. Operating with platinum needles or pointed plates, as before, if one of the needles is inserted into the parenchyma of a stem or any branch of a plant and the other in moist soil at some distance from the root (several yards for example), there will always be a current, showing that the earth contains an excess of positive electricity and the parenchyma an excess of negative. The deviation varies with the humidity of the soil and the sappy state of the plant, but may be 15, 20, 30, 40 degrees, or even more.

The magnetic needle that deviates to 15 degrees, stops at 8 degrees after oscillating for a while; it still diminishes very slowly to 2 or 3 degrees, owing to the polarity acquired by the platinum; if this polarity is destroyed by moving the needle in the ground without withdrawing it, the deviation increases 2 degrees; while the same effect on the other needle restores the deviation to its first amount. This greater effect with the latter is owing to the fact that as the sap in contact with the needle is altering more or less rapidly, the current would have a new energy when the altered bed is disturbed by friction. There is little or no effect when one of the needles is in the wood or pith. But if inserted in a number of leaves, while still on the branches, the result is similar to that obtained from the parenchyma, proving a similar constitution for the sap of both.

The same effects are obtained from all plants, even the herbaceous. We may then receive as a principle, that in the act of vegetation, when germination is accomplished, the ascending sap, which communicates with the soil through the roots, carries up an excess of positive electricity, whilst the parenchyma sap furnishes to the air by aqueous evaporation an excess of negative electricity. Vegetation therefore acts the reverse of the causes which ordinarily render the air positive and earth negative. It is probable that the electric effects thus produced, as they are incessant, should exert, especially in tropical regions and wooded countries, considerable influence upon the electric state of the atmosphere which plays so important a part in the production of meteoric phenomena.

As the cambium, or the substance so designated, is negative compared with the wood and pith occupying the central part of the plant, the positive state of the parenchyma as related to the cambium, has only a secondary influence upon the effects

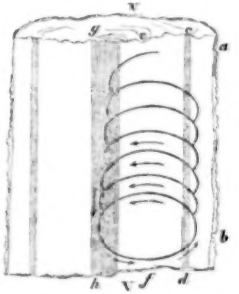
just mentioned, since the direction of the primitive current is not affected by it.

III. *Are there direct Electric Currents in Plants.*

May we conclude from the facts presented in the first part of this memoir that there are constant electric currents circulating in plants and also between them and the earth? This question is important to physiology, since such currents cannot circulate in liquids without producing chemical action: and it is of no less interest to the meteorologist. To reply to it, we must consider whether the two conditions necessary for the production of such currents are fulfilled.

The *first* undoubtedly exists, as there are present two different liquids reacting chemically upon one another through a medium of permeable tissues: and it is the same with the *second*, which requires the contact of two liquids by insensible transition. In fact, in a horizontal section of a stem of a plant, the immediate communication takes place readily through the tissues between the ascending sap and the parenchyma sap. In a longitudinal section, it is well known that the ascending sap, before it enters the plant by the roots, consists of water including some air, carbonic acid gas, and small quantities of saline and organic matters taken up from the soil. In its passage, it dissolves by degrees a portion of the substances met with along its course, acquires increased density, and constitutes then the *ascending sap*. The parenchyma sap, after elaboration in the leaves, loses a portion of its constituent parts in the process of nutrition. Each is in the condition necessary for mutual contact by insensible transition, and consequently for producing electric currents without the addition of metallic plates.

These currents ought to circulate as in the annexed figure. VV is a longitudinal section of a plant; *ab* the bark; *cd*, the cambium; *ef* the wood; *gh* the pith. Positive electricity entering at *h* and *f* through the roots, and ascending in the direction *ba*, produces, as appears from the facts, partial currents proceeding from the bark to the pith, and this even to the extreme branches.



We are not able to make other inductions from the facts thus far observed, nor point out the chemical action resulting from such currents in the tissues. New experiments are necessary before we can know what to believe on these points.

Recapitulation.—The observations presented in this memoir establish the following facts:

1. The production of derived currents in the stems of plants by the aid of platinum needles, inserted, one into the bark, the other into the wood, which currents have a direction from the parenchyma to the pith.

2. The production of similar currents in the bark proceeding from the cambium to the parenchyma, having an inverse direction as compared with the former.

3. The sap of the cortical parenchyma, held exposed to the air for some instants, undergoes such a modification that when put again in contact with the parenchyma sap, it becomes relatively negative.

4. The production of derived terrestrial currents, through the medium of the roots from the pith and other parts of the stem.

5. The direction of the terrestrial currents shows that in the act of vegetation, the earth takes constantly an excess of positive electricity, and the parenchyma of the bark and the leaves an excess of negative electricity which is transmitted to the air through the exhaled water.

6. The distribution of the ascending sap and the sap of the cortical parenchyma leads to the belief that there are currents circulating continually in plants, directed from the bark to the pith, passing by the roots and earth, and perhaps without passing by these two intermediaries.

7. Chemical reactions are the first cause, beyond doubt, of the electric effects observed in plants. These effects are very varied, and have thus far been observed only in a small number of cases.

8. The opposite electric states of plants and the earth give reason for concluding, that through the great extent of vegetation over the continents and islands, they exert a decided influence upon the electric phenomena of the atmosphere.

Art. XIV.—*On the Rings of Saturn;* By G. P. Bond, Assistant at the Observatory of Harvard University.*

The question of the multiple divisions of the ring of *Saturn* has engaged the attention of astronomers from an early period. Cassini appears to have been the first to notice the primary division, though he has placed it midway between the inner and the outer edges.

This interval is always visible with a good telescope, but much nearer to the outer edge than Cassini describes it to be. Short, next, with a telescope of twelve feet focus, probably a reflector,

* Cited from the Astronomical Journal, vol. ii, No. 1 and 2.

saw two or three divisions outside of the center of the ring; a figure is given in Lalande's Astronomy. In June, 1780, Sir W. Herschel noticed, on four different nights, a division near the inner edge. From its never, either previously or subsequently, having been seen by him, it is probable that the subdivisions are not permanent; otherwise they could scarcely have escaped detection under the scrutiny to which he subjected every thing appertaining to the system of *Saturn* for thirty or forty years. This inner division is figured and described in the *Philosophical Transactions* for 1792. In Gruithuisen's *Astron. Jahrbuch*, for 1840, pp. 103–105, mention is made of lines seen on both rings in 1813 and 1814. Quetelet, at Paris, with an achromatic of ten inches' aperture, saw the outer ring divided in December, 1823.

On the 17th of December, 1825, and on the 16th and 17th of January, 1826, at least three divisions were seen on the outer ring by Captain Kater. A full account, illustrated with engravings, has been published in vol. iv, Part II, of the Memoirs of the Royal Astronomical Society. This contains also a collection of the accounts of previous observers. Two reflectors of the Newtonian form were used, of between six and seven inches' aperture.

At Berlin, on the 25th of April, 1837, the outer ring was seen by Professor Encke, with perfect distinctness, divided into two nearly equal parts, and several divisions were recognized on the inner edge of the inner ring. The great equatorial of the Berlin Observatory was used with an achromatic eyepiece.

On the 28th of May, the place of the outer secondary interval was determined. The great optical capacity of the telescope, and the eminence of Professor Encke as an observer, give the highest value to these observations. They are found in the *Astr. Nachr.*, No. 338. No. 357 of the same volume has a notice of several divisions on both rings, seen by De Vico, at Rome, with the equatorial of the Roman College, the object-glass of six inches, by Cauchoix. A letter from M. Decuppis, *Comptes Rendus*, vol. vii, gives a description of several divisions seen at Rome, in May, June, and July, 1838.

On the 7th of September, 1843, a division of the outer ring was detected by Messrs. Lassel and Dawes, at Starfield. They employed a Newtonian reflector of nine inches' aperture; the details are to be found in vol. vi, of the Monthly Notices of the Royal Astronomical Society.

The newly discovered inner ring of *Saturn* cannot properly be classed with the subdivisions of the old ring, as it lies within its inner edge.

We have, then, the best assurance in the number and reputation of those who have described the phenomena in question,

that to set aside these appearances by referring them to some optical deception on the part of the observer, or to some defect in his instrument, is an explanation altogether insufficient and unsatisfactory. On the other hand, we know that some of the best telescopes in the world, in the hands of Struve, Bessel, Sir John Herschel, and others, have given no indication of more than one division, when the planet has appeared under the most perfect definition. The fact, also, that the divisions on both rings have not usually been visible together, and that the telescopes which have shown distinctly several intervals in the old ring have failed to reveal the new inner ring, while the latter is now seen, but not the former, may be taken as some evidence that the difference is not probably owing to any extraordinary tranquillity or purity of the atmosphere, nor to any peculiarly favorable condition of the eye or instrument, but rather to some real alterations in the disposition of the material of the rings.

Admitting this, the idea that they are in a fluid state, and within certain limits change their form and position in obedience to the laws of equilibrium of rotating bodies, naturally suggests itself. There are considerations to be drawn from the state of the forces acting on the rings which favor this hypothesis. For instance, on the assumption that the matter of which the ring is composed is in a solid state, we may compute for any point on its surface the sum of the attractions of the whole ring and of *Saturn*. The centrifugal force, generated by its rotation, may then be determined from the condition that the particle must remain on the surface. Now in the case of a solid ring, particles on the inner and outer edges must have the same period of rotation. This condition limits the breadth of the ring, for if it be found necessary for the inner and outer edges to have different times of rotation, this can be accomplished only by a division of the ring into two or more parts. In this way Laplace has inferred the necessity of there being several rings. From a more exact analysis, M. Plana, in the *Mem. Acad. Turin*, vol. xxiv, concludes that more than one ring is not essential. The data which he assumed we now know to have been very wide of the truth, as regards the mass and thickness of the ring.

Bessel's last determination of the mass derived from the progressive motion of the line of apsides of the satellite *Titan*, which amounts to a very sensible quantity, makes that assumed by Plana at least thirty times too large. If Bessel's mass be received, the necessity of numerous rings can scarcely be questioned.

If the density of the ring be the same with that of *Saturn*, and its matter uniformily distributed with Bessel's mass $= \frac{1}{1\,1\,3}$ of *Saturn's*, its thickness, seen from the earth, would only subtend an angle of $\frac{1}{2\,5}$ of a second of arc. It is a confirmation of the

mass adopted, that this does not vary more from that derived from observation, than we can attribute without improbability to a difference of density between the ring and *Saturn*. Sir John Herschel states, *Outlines of Astronomy*, p. 315, that it cannot be so large as one twentieth of a second. In the *Astronomical Journal* for January, 1850, I have given as the result of observations with the great refractor at Cambridge, during the disappearance of the ring in 1848–49, a thickness not exceeding one hundredth of a second. We cannot suppose the mass to be greater than that assigned by Bessel, without also admitting a density much greater than that of *Saturn*, the smallest observed thickness already requiring a density more than three times that of the planet.

In the calculations which follow, I have supposed the mass of the ring not greatly to exceed $\frac{1}{1}\frac{1}{8}$ of *Saturn*, and its thickness $\frac{1}{4}\frac{1}{3}$th of a second. For the other elements I have used Struve's measurements.

The analysis of the attraction of the ring presents great difficulties. Laplace has taken as an approximation for a very narrow ring the attraction of a cylinder of infinite length, having for its base an ellipse. Plana takes account of the curvature by assuming the breadth to be very small compared with its radius. But if more than the first term is taken into account, the numerical calculations become very complicated. These difficulties may in part be avoided by taking account of the form of the surface only in the immediate neighborhood of the point attracted. In all the parts distant compared with the thickness, it is sufficient to suppose the whole mass collected in the plane of the center of the rings. This plane, considered as made up of parallel straight lines, attracts the particle by the sum of the attractions of its elements. The attraction of each line parallel to its length, y being its perpendicular distance from the radius joining the attracted particle with the center, and r and r' the distances of its extremities from the same point, will be $\left(\frac{1}{r}-\frac{1}{r'}\right)dy$.

From which the attraction of a plane surface is easily computed by quadratures. For the ring on the surface of which the attracted particle is, and for the two next adjacent, I have used Laplace's formula, *Mécanique Céleste*, vol. ii, [2092]. This assumes the figure of the surface to be elliptical; in the absence of any certain knowledge of its form, this has the recommendation of simplicity and of satisfying also the conditions of equilibrium. The hypothesis of any other figure would not materially affect the conclusions arrived at, provided the mass and density be not altered. The numbers thus obtained are only approximations to the truth, but are sufficient for the object in view.

If we adopt for unity the radius of the outer edge of the outer ring, we have from observation the thickness of the ring $=2b<\frac{1}{8\,8\,8}$. Let r and r' be the radii of the inner and outer edges, and i the interval between two adjacent rings,

$$r_0=\frac{r+r'}{2},\ 2a=r'-r.$$

Any intervals permanently existing so large as one half, or even one third, of that usually seen, could not escape observation. Moreover, if the subdivisions are numerous, the width of the intervals must be proportionally diminished, because the whole area occupied by them goes to diminish the amount of light reflected, and to increase the density of each ring, both of which are already large. The light of the ring being sensibly brighter than that from an equal area on the ball, it is not probable that any considerable part of the light of the sun is transmitted through intervals. And to preserve the same mass, if the intervals are large, the matter must be compressed, as it is not allowable to give a thickness greater than is indicated by observation. To avoid the hypothesis of a reflective power, and a density greater than we are warranted in assuming, we must, therefore, consider the intervals to be very narrow. We may take, then, the width of all but the known interval as certainly less than 0·01, which is one half of the width of the known interval. From the blackness of the shadow of the ring upon the ball, which would be diminished in intensity were a considerable part of the sun's rays transmitted, we may infer that the intervals which reflect no light at all cannot occupy an area so large as one fourth of the average breadth of the rings; that is, $r'-r>0{\cdot}04$.

The above are very liberal allowances, but it is important to assume the intervals as large as possible, so as to diminish the chances of a collision, which at best is almost inevitable.

We come now to consider the forces acting on the rings.

If f' be the force with which a particle at the outer extremity of the major axis of a ring is attracted to its surface by the sum of the attractions of all the rings, f the same force for the inner edge, s the mass of *Saturn*, and t the time of revolution of any ring in days, the centrifugal force at the distance r will be $=\frac{kr}{t^2}$, log. $k=9{\cdot}1207$.

Then, in order that the particle should remain on the surface, we must have

$$f>\frac{s}{r^2}-\frac{k}{t^2}r;\ f'>\frac{kr'}{t^2}-\frac{s}{r'^2}.$$

Therefore,

$$r'-r<\frac{r_0^{\,3}}{3s}(f+f').$$

If we put $F=\frac{s}{r_0^2}$ = the attraction of *Saturn* on the middle of any ring, we obtain the relation,

$$\frac{f+f'}{F}>3\frac{r'-r}{r_0}.$$

From the smallness of the mass of the ring, as well as from its unfavorable distribution, it is easy to see that $r'-r$ must be very small compared with r_0.

To obtain f and f', I have computed from Laplace's formula the following values: f_0 is the attraction of a single ring upon a particle on its surface, at the extremity of the major axis of its base; f_1 and f_2 the attractions of the two next adjacent. The interval between $=0{\cdot}01$, $2b=\frac{1}{100}$. The radius of the outer edge of the outer ring being $=1$.

Attractions of Three Narrow Rings.

	f_0	$\frac{f_1}{f_0}$	$\frac{f_2}{f_0}$
$a=0{\cdot}01$	$+0{\cdot}00661$	$-0{\cdot}284$	$+0{\cdot}134$
·02	679	·393	·150
·03	685	·460	·154
·04	689	·507	·157
·05	691	·543	·160
·06	692	·571	·162
·07	693	·594	·164
·08	693	·614	·165
·09	694	·631	·166
·10	$+0{\cdot}00694$	$-0{\cdot}646$	$+0{\cdot}166$

The attraction of the whole ring, considering its mass to be uniformly distributed, I have next computed by quadratures. Breadth of whole ring $=0{\cdot}335$. Radius of outer edge $=1$.

Distance of particle within the outer edge				$=0{\cdot}0075$	Attraction	$=+4{\cdot}52\times$ mass of ring.
"	"	"	"	·0475	"	2·42
"	"	"	"	·0875	"	1·70
"	"	"	"	·1275	"	1·16
"	"	"	"	·1675	"	0·61
"	"	"	"	·2075	"	$+0{\cdot}04$
"	"	"	"	·2475	"	$-0{\cdot}52$
"	"	"	"	·2875	"	1·32
"	"	"	"	·3275	"	$-3{\cdot}53$

These two tables give the means of finding f and f' with sufficient exactness. For *Saturn* we have

$S=\frac{4}{3}\pi\left(\frac{17''{\cdot}7}{40''{\cdot}095}\right)^3$; log. $S=9{\cdot}5567$; log. mass of ring $=7{\cdot}4848$.

The density of the ring is assumed $=$ *Saturn's*, unless it be otherwise stated. A change in the density affects only that part of the ring's attraction depending on f_0, f_1, and f_2.

But $f+f'$ will be changed very nearly in the direct ratio of the different densities when the rings are narrow.

We will first suppose the case of but one ring without division.

$r=0{\cdot}665$ $\qquad$ $r'=1{\cdot}000$

$r_0=0{\cdot}8325$ $\qquad$ $r'-r=0{\cdot}335$

Upon a particle at a distance within the outer edge $=0{\cdot}21$, the attraction of the whole ring becomes $=0$. This gives for the time of rotation $t=0{\cdot}43$. The excess of *Saturn's* attraction over the centrifugal force at the inner edge $=0{\cdot}37$. At the outer edge the centrifugal force is in excess by 0·33. We must therefore have,—

$f>0{\cdot}37$ $\qquad$ and $f'>0{\cdot}33$

But $f=0{\cdot}0040$ $\qquad$ and $f'=0{\cdot}0070$

Assumed value of $r'-r=0{\cdot}335$

Required " $<0{\cdot}0058$

If there be but one ring, it will be necessary to increase its attractive force by sixty times its probable value, in order to retain its particles on its surface.

With a single division into two equal rings, we have for the inner of the two, giving such a time of rotation as will retain particles on the middle from leaving their place,

$t=0{\cdot}39$ $\qquad$ $r=0{\cdot}665$ $\qquad$ $f>0{\cdot}25$ $\qquad$ $f'>0{\cdot}19$

$r'=0{\cdot}8325$ $\qquad$ $f=0{\cdot}0050$ $\qquad$ $f'=0{\cdot}0042$

$r'-r=0{\cdot}1675$ $\qquad$ $r'-r$ computed $=0{\cdot}0036$

For the outer ring,

$f=0{\cdot}0012$ $\qquad$ $f'=0{\cdot}0081$

$r'-r<0{\cdot}0066$ computed.

$r'-r=0{\cdot}1675$ assumed.

As no change of mass or density within the limits of probability will account for so large differences, we must therefore still further reduce the width of the rings.

By trying different values, it will be found necessary to diminish $r'-r$ so far, that the intervals occupy nearly as much area as the reflecting surface, which cannot be admitted, for reasons before given.

We will take $r'-r=0{\cdot}02$, which corresponds to eleven equal rings distant from each other by 0·01.

For the outside ring,

$t=0{\cdot}59$ $\qquad$ $f>0{\cdot}0023$ $\qquad$ $f'>0{\cdot}0202$

$f=-0{\cdot}0036$, tendency is from the surface.

$f'=\ 0{\cdot}0144$

$r'-r<0{\cdot}0097$ computed.

$r'-r=0{\cdot}0200$ assumed.

For the middle ring,

$f > 0{\cdot}0172$ $\quad f' > 0{\cdot}0205$ $\quad t = 0{\cdot}46$
$f = 0{\cdot}0046$ $\quad f' = 0{\cdot}0075$
$r' - r < 0{\cdot}0064$ computed.
$r' - r = 0{\cdot}0200$ assumed.

For the inner ring,

$f > 0{\cdot}0415$ $\quad f' > \ 0{\cdot}0288$ $\quad t = 0{\cdot}34$
$f = \ {\cdot}0113$ $\quad f' = -0{\cdot}0004$
$r' - r < 0{\cdot}0031$ computed.
$r' - r = 0{\cdot}0200$ assumed.

In order to preserve the mass as previously adopted, we must suppose an average density about three times that of *Saturn*. By recomputing f and f' for the inner ring with a density $=3$, we obtain,

$f = +0{\cdot}0263$ $\quad f' = +0{\cdot}0091$
$r' - r < 0{\cdot}0101$
$r' - r = 0{\cdot}0200$

A density six times that of *Saturn* would just suffice to retain the particles on the surface of the inner ring. To effect this without changing the mass, we must diminish b in the same proportion. But the attraction of a thin and narrow ring upon a particle at the extremity of its major axis varies nearly as $b \times$ density. *Mécanique Céleste*, vol. ii, [2095]. Therefore f is not increased when we increase the density by diminishing b.

If a further diminution of width is attempted, a difficulty is encountered in the width of the intervals.

In the last case, suppose the area occupied by the intervals is already double the limit previously assigned. If we lessen the space occupied by the intervals, by bringing the adjacent rings nearer together, f decreases instead of increases.

But there are still stronger objections to a large number of small rings near to each other.

It is known in the case of a single ring, that, if it were perfectly uniform in every part of its circumference, the slightest exterior disturbance would precipitate it upon the body of the planet. To avoid this catastrophe, we must suppose each ring to be an irregular solid, its center of gravity not coinciding with its center of figure, but having a motion of rotation about the body of *Saturn*. In addition to this, a number of regular concentric rings are in a position of unstable equilibrium, by virtue of their own mutual attractions. The slightest inequality in the intervals would have the effect of throwing the whole system into confusion.

Let us suppose, for instance, that the inner ring deviate by ever so small an amount from an exact central position with ref-

erence to the ring outside it. The nearest sides commence moving together, until they come in contact. All the others must follow. The consequence of such a conflict of these masses, each urged by different velocities, corresponding to the different times of rotation of the several rings, must be fatal to the whole structure.

It is therefore again necessary that the rings be not of regular figure or density.

But if these irregularities are small, there will be only a feeble resistance opposed to their tendency to fall upon the body of the planet.

On the other hand, if they be large, they will become the source of mutual disturbances, which must end in their destruction, by causing them to fall upon each other. The smallness of the intervals between them, and the near equality in the period of rotation of two adjacent rings, will make the danger of the latter event imminent, if not wholly unavoidable.

The nearness of the rings will in any case render it impossible that they can assume a figure of equilibrium permanent or nearly so.

The hypothesis that the whole ring is in a fluid state, or at least does not cohere strongly, presents fewer difficulties.

There being no longer an unyielding coherence between the particles of the inner and outer edges, they have not necessarily the same period of rotation about *Saturn*. A continual flow of the inner particles past the outer may be supposed, by which the centrifugal force will be brought into equilibrium with the other forces. And even should an accumulation of disturbances, of which the absence of inequalities lessens the probability, bring the rings together, the velocities at the point of contact will be very nearly equal, and the two will coalesce without disastrous consequences.

If in its normal condition the ring has but one division, as is commonly seen, under peculiar circumstances it might be anticipated that the preservation of their equilibrium would require a separation in some regions of either the inner or outer ring; this would explain the fact of occasional subdivisions being seen. Their being visible for a short time, and then disappearing, to the most powerful telescopes, is accounted for by the removal of the sources of disturbance, when the parts thrown off would reunite.

Finally, a fluid ring, symmetrical in its dimensions, is not of necessity in a state of unstable equilibrium with reference either to *Saturn* or to the other rings.

Art. XV.—*On the Constitution of Saturn's Ring;* by Prof. B. Peirce of Harvard University.

Abstract of a paper read before the American Association for the Advancement of Science, at the meeting at Cincinnati.

A memoir upon Saturn's Ring, by Mr. George P. Bond, was read to the American Academy of Arts and Sciences, upon the 15th of April, and was the occasion of the present investigation. Since Mr. Bond's paper is still unpublished, I shall be obliged to make constant reference to it, and even recapitulate some parts of it, in order that the proper relation of the two paths of research may be correctly understood.

1. The author of the Mecanique Celeste proved that Saturn's ring, regarded as solid, would not be sustained about the primary, unless it had decided irregularities in its structure. But the observations of Herschel and others have failed to detect any indications of such irregularity, and a laborious series of observations have finally convinced Mr. Bond of the utter improbability of any important irregularities, and he has, therefore, adopted the conclusion that *Saturn's ring is not solid but fluid.* Mr. Bond's argument is chiefly derived from observation; whereas a new investigation of the mechanical conditions of the problem has led me one step further. I am now convinced that *there is no conceivable form of irregularity and no combination of irregularities, consistent with an actual ring, which would permit the ring to be permanently maintained by the primary if it were solid.* Hence it follows, independently of observation, that Saturn's ring is not solid. And now it is worthy of remark that if we adopt, as the basis of calculation, the mass of the ring which was determined by Bessel, the thickness from Bond and the other dimensions from Struve, we shall find the density to be about one-fourth more than water. So that the ring consists of a stream, or of streams of a fluid rather denser than water, flowing around the primary.

2. Mr. Bond next undertook a series of very ingenious and novel computations, in order to determine from theoretical considerations alone whether the ring was one or many, and arrived at the remarkable result that *neither of these hypotheses was tenable.* He is, therefore, disposed to reconcile the discrepancies of observation in this respect by supposing the constitution of the ring to be variable; and that, although the principal division, which has been always observed, is permanent, *the other divisions are constantly annihilated by the mutual concussions of the rings, and again reproduced by some process which he does not undertake to define.* This bold theory is fully sustained by my own analytical investigations, and not only do my researches ex-

hibit the possibility of this strange phenomenon, but they even show the precise mode of action and how it must be the case of nature. If the ring had been originally one, it would soon have subdivided itself at definite points, which can be exactly computed, into portions of a determinate width. The disturbing causes must, however, drive these separate rings, sooner or later, against each other. There must then follow an interchange and crossing of currents, a mutual retardation, a momentary state of equilibrium as one ring and then another was breaking up, when the same process would be repeated in endless succession.

3. But even a fluid ring would not be permanently retained by the direct action of the primary. For whatever may be its figure, the velocity of its current must be slower at the points which are more remote from the planet; so that there must be an accumulation of fluid at these points. An exact analysis shows that the accumulation precisely balances the greater distance, and hence the ring is attracted equally in every direction. The regulating action upon the motion of the center of gravity is, therefore, cancelled; and it must continue to move uniformly in any direction in which it may have been started by a foreign influence. It must move on until it is destroyed by striking the surface of the planet. How has Saturn's ring escaped this catastrophe? Simply, because the disturbing forces have counteracted their own effects. The satellites are constantly disturbing the ring; but, in the very act of perturbation, they are sustaining it in its place. Their sustaining action is not negative, but positive; and without satellites there can be no ring. The theory of this curiously sustaining power may be variously illustrated. In the first place, each particle of the ring may be regarded as a satellite, which the other satellites disturb in the usual way. Thus the mean distance from Saturn is not varied in the least, and the disturbance of the eccentricity can only reach certain definite limits, after attaining which it must diminish. Secondly, in consequence of the attraction of its satellites, Saturn describes an orbit about the common center of gravity of the system; each particle of the planet tends to move in this same orbit. The center of gravity of the ring must, likewise, tend to describe nearly this same orbit, and its orbit would be precisely the same if the attraction of the ring for the satellites were the same as if its mass were accumulated at its center of gravity. But the deviation may be safely neglected and referred to the class of periodical perturbations.

4. It follows, then, that no planet can have a ring, unless it is surrounded by a sufficient number of properly arranged satellites. Saturn seems to be the only planet, which is in this category; and it is the only one, therefore, which could sustain a ring. Our Sun, also, does not appear to have its satellites properly disposed

for supporting a ring; and the only part of the system where such a phenomenon might have been reasonably expected, is just within the powerful mass of Jupiter. But had there been a ring at this part of the system, it must have been subject to such extraordinary perturbations, that it would in the course of time have been vibrated up against the next interior planet, Mars; and, in this way, have been broken into the asteroids. The orbits of planets formed under such circumstances would have been naturally characterized by great eccentricity.

5. But suppose that, from any cause whatever, the Sun had, at some period, been surrounded by a light ring comparable in levity to the zodiacal light; and in order to escape the planetary influences, we may suppose the plane of the ring to have had a large inclination to the ecliptic. The result would have been that the center of gravity of the ring would have soon begun to move in some direction or other, and have continued moving until it was brought against the surface of the Sun. But during this motion, and in consequence of the solar action, the matter of the ring would have accumulated at the most remote part; so that if the Sun were a mere point, it would have happened that, at the very instant of its expected meeting with the ring, the whole ring would have escaped from the point of compact. The experiment of Tantalus would have been performed on a grand scale, and the ring would have been instantaneously transformed into a comet in its aphelion.

6. If, however, the ring were supposed to be a large gaseous mass of a circular figure, the condensation which would occur at the point of aphelion might soon lead to chemical action. Precipitation might ensue, and the necessary consequence would seem to be a continually accelerated accumulation at this point, which would terminate in the production of a planet.

I stop upon the verge of the nebular hypothesis. I appeared before this Association a few years ago when it was still in its primitive geological condition, with an argument which seemed to me at the time to be incontrovertible, against this theory. I then maintained that, although it stood upon three legs, it was nevertheless infirm in its position; for that one leg was too long, a second was too short, and the third was wholly dilapidated. I am not yet disposed to retract my opposition, nor shall I, at once, sacrifice my former unanswerable arguments upon the altar of a new investigation. But I am free to admit that the farther I extend my researches into the physical universe, the stronger appears to me the evidence that the process of creation was conducted by the divine geometer in a modified form of that very hypothesis, which was contrived by a shallow and wicked philosophy for the direct purpose of excluding the Deity from his own works.

ART. XVI.—*On Saturn's Ring;* by DANIEL KIRKWOOD, A.M., Principal of Pottsville Academy.

Messrs. Editors:—I have just seen an abstract of Prof. Peirce's paper, "*On the Constitution of Saturn's Ring*," read before the American Association at its recent session in Cincinnati. I had for some time doubted the truth of the generally received theory of the solidity of this extraordinary girdle. To myself, therefore, the reasoning and conclusion are especially interesting. The following remarks on the same subject are taken from a lecture written a year since, and publicly delivered in the city of Reading on the 3d of January last. Should you deem them worthy of publication they are at your disposal.

The late discovery of a remarkable harmony in the rotations of the planets, gives additional interest and importance to a variety of questions bearing upon the theory of the genesis of our system. The rotation of Uranus—the physical constitution of the Sun—the law of the planetary distances—the relative ages of the planets—the rings of Saturn—all are subjects claiming the earnest attention of scientific men, and holding out encouraging hopes of future discoveries.

* * * A mistake appears to have generally obtained with respect to the epochs at which, according to the nebular theory, the various members of our system assumed a planetary form. "In this hypothesis," remarks Poutecoulant, "the formation of the planets would not have been simultaneous; they have been created successively at intervals of ages; the oldest are those which are farthest from the Sun, and the satellites are of a more recent date than their respective primaries." On the same subject Prof. Lovering, of Cambridge, Mass., says:—"It cannot be declared to be beyond the reach of the enginery of the mathematician, to be able to settle with exactness the genealogy of our system according to Laplace's theory, and to assign the individual year when each of the outcast planets, from the gray Herschel and Saturn down to the infant Mercury, left its burning home and became an independent orb." In regard to this question it may be proper to remark, that the epoch of the disjunction of a ring from the central mass, and that of its assuming a spherical form, would be separated by an immense interval. The most distant annuli, or those first abandoned, would require a much longer period to agglomerate around a nucleus than those of more recent origin. It is evident also that the planets having a greater "sphere of attraction" would require a proportionally greater length of time for the process of condensation. Taking these facts into consideration, it would seem that the planets nearest

the Sun may have been the first to assume their present dimensions. Of the major planets, Saturn has the greatest "sphere of attraction," and hence the duration of its *forming period* must likewise have been greatest. This gives rise to the interesting question whether the ring of Saturn may not be the most recent cosmical formation within the limits of the solar system, and whether it may not, in the course of future ages collect about a nucleus and constitute a satellite. The evidence of its solidity is not, I think, by any means conclusive. On the other hand, observations made within the last few years give a degree of plausibility to the presumption that it may be in a state of fluidity. I refer to the occasional appearance of dark lines, chiefly on the outer ring, which have been supposed to indicate a subdivision into several concentric annuli. They do not, however, appear to be permanent; at least they are subject to some change, as they are not always visible, even when circumstances would seem most favorable. It has also been found by delicate micrometrical measurements of the rings, that they are not of uniform thickness. May not this accumulation of matter on one side be the incipient nucleus of a satellite? If so, it will be reserved for future astronomers to witness a scene no less amazing than the formation of a new world within the limits of the solar system.

If we admit the truth of the nebular hypothesis, it becomes an interesting question whether the chaotic matter advanced with regularity through all the stages of condensation, or whether its contractions were sudden and violent. The former supposition appears to have been generally entertained by writers on the subject; but the latter, as has been observed by Prof. Nichol, seems more in harmony with the known operations of nature around us. When gaseous substances pass to a liquid state it is not generally by gradual condensation: on the other hand, such changes are characterized by rapid and energetic action. The same is true in most cases when a body passes from a liquid to a solid state.

It affords me the highest gratification to know that the attention of some of the most distinguished mathematicians of our country has been directed to the investigation of the interesting questions to which I have referred. And although in all probability the subject cannot be exhausted for many years—perhaps for ages—the progress of research leaves little room to doubt the speedy development of important results.

Pottsville, Pa., May 19th, 1851.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Rotation of the Plane of Polarization produced by the Galvanic Current.*—Wiedemann has presented a memoir upon this subject which is of special interest and importance from its containing the results of the only series of *quantitative* experiments with which science has been enriched. The apparatus employed was similar in principle to that used by Bloch in his determinations of the power of rotation of rock-crystal with reference to the fixed lines of the spectrum. A ray of light was introduced into a dark room by means of a heliostat, and after passing through a narrow vertical slit traversed the polarizing apparatus which consisted of two Nicol's prisms, the first fixed, the second moveable round its axis and carrying a vernier applied to a graduated circle and reading to 5′. Between the two Nicol's prisms was placed the substance to be examined. Behind the second Nicol, at a distance of from 6 to 8 feet, was placed a Galilean telescope magnifying about 15 times, and in front of the objective of this, a flint glass prism which received the rays which had traversed the polarizing apparatus. Under these circumstances the light was polarized by the first Nicol in a definite plane which by the action of the interpolated substance received an angular deviation, and this deviation was of course different for rays of different colors; the second Nicol then extinguished that color the plane of polarization of which was perpendicular to the plane of vibration of the Nicol. The spectrum formed by the flint-glass prism and observed through the telescope exhibited therefore only those colors which had passed through the polarizing apparatus, and these with a greater or less brightness according as their plane of vibration was less or more inclined to the plane of vibration of the second Nicol. In place of the color extinguished by this last, a black band was seen in the spectrum: when the second Nicol is turned round this band wanders from one end of the spectrum to the other, as the plane of vibration of the Nicol becomes successively perpendicular to the planes of polarization of the different colors. In the unextinguished portion of the spectrum the lines of Fraunhofer were distinctly to be seen; the cross-wires of the telescope were then brought to coincide with one of these lines, and then the second Nicol turned till the dark band in the spectrum coincided with the wires and consequently also with the fixed line selected; the angle through which the Nicol had been turned gave then the angle of rotation corresponding to the given fixed line. In this manner it was easy to determine the angle of rotation for the different wave lengths corresponding to the lines B, C, D, E, b, F and G, as had been done by Bloch for plates of rock crystal. To test the accuracy of the method, oil of lemon and different kinds of oil of turpentine were examined; the results reduced to lengths of 100^{mm} were as follows:

	B	C	D	E	b	F	G
1. Turpentine,		10·9	14·05	18·7	19·6	23·2	32·75
2. Turpentine,	21·5	23·4	29·3	36·8	38·3	43·6	55·9
3. Oil of lemon,	34·0	37·9	48·5	63·3	66·4	77·5	106·0

The turpentine No. 1, was pure and had been rectified in a current of steam, its rotation was towards the right; No. 2, was another variety which had not been rectified and turned the plane of polarization to the left; the oil of lemon was also pure and distilled like No. 1: the author found that with pure oil of turpentine the observed angles of rotation never differed more than 5′ from the mean, whereas with oil of lemons the differences were much greater, the turpentine was therefore preferred for experiments with the galvanic current. The galvanic apparatus employed consisted of two helices of copper wire $2{\cdot}3^{mm}$ in thickness, and weighing each about 6 lbs.; they were placed with their axes in the same straight line and had together a length of about 9 inches; in the axis of these coils was placed the tube containing the liquid to be examined. The current from a battery of about 30 pairs, (partly Grove's, partly Bunsen's and partly iron-zinc,) was made to pass through a gyrotrope, a tangents-compass, and the whole length of the coils themselves. In this manner the author studied the deflecting action of the current upon the plane of polarization in bisulphid of carbon and in oil of turpentine; the result of his investigation he gives in the following statements.

(1.) The law of Biot, according to which the rotation of the plane of polarization of any color is inversely proportional to the square of its wave length does not hold good for oil of turpentine or oil of lemon, any more than for rock-crystal, (as shown by Bloch.)

(2.) The law of Faraday, according to which the deflection of the plane of polarization is proportional to the intensity of the deflecting current, holds good for those substances, which in themselves deflect the plane of polarization, as well as for those which do not do so.

(3.) The deflection of the plane of polarization of different colors by the galvanic current is in the case of rotating as well as not-rotating substances, greater in proportion as the wave length of the color in question is less. In *rotating* substances like oil of terpentine, this deflection is proportional to the deflection produced by the substance itself upon the plane of polarization of each particular color.—*Pogg. Ann.*, 1851, *No.* 2.

2. *Physical Demonstration of the Rotation of the Earth by means of the Pendulum.*—Foucault has communicated to the Academy of Sciences an account of an experiment which has excited universal attention and interest, and which has since been frequently repeated with success. The experiment consists simply in suspending a heavy ball to a long and flexible string, and allowing the whole to vibrate freely in the manner of a pendulum; under these circumstances it will be found that the plane of vibration gradually changes its position, turning slowly from east to west. To understand what takes place in this case, it is necessary to consider first the experiment as made at the pole, and the pendulum as suspended from a point in the axis of the earth prolonged and independent of the motion of the earth itself; it is evident that in this case, as the earth moves from west to east the plane of vibration of the pendulum which is in reality fixed, will appear to move from east to west. Next suppose the pendulum suspended from a point in the axis of the earth prolonged, but attached to and moving with the earth itself, it is evident, and it may easily be demonstrated

by experiment, that the rotation of the point of suspension will not affect the plane of vibration of the pendulum, and the result will be the same as before; the plane of vibration will appear to revolve uniformly, making a complete revolution in twenty-four hours. If we transfer the point of suspension from the pole to the equator, this point will then revolve with the earth and the plane of vibration will undergo no apparent change: but if we transfer the pendulum to a point between the pole and the equator, it is clear that while the point of suspension will itself revolve uniformly with the earth, the plane of vibration of the pendulum will be carried round but less rapidly than the earth, the result will therefore be that the plane of vibration will move *with reference to the earth* from east to west, but more slowly than at the pole. Foucault finds, by two different methods, that the angular motion of the plane of vibration is equal to the angular motion of the earth in the same time multiplied by the sine of the latitude. The experiment in question has been made upon a large scale in the Pantheon at Paris, the length of the cord, and consequently the time of vibration of the pendulum allowing the apparent motion of the plane of vibration to become very distinctly evident after only a few oscillations.—*Comptes Rendus*, xxxii, p. 135. [The experiment has been repeated in this country and England.]

3. *Equivalent of Bismuth.*—Schneider has made a new determination of the equivalent of bismuth, and has obtained results which appear to be well worthy of confidence. Commercial bismuth was dissolved in pure nitric acid, the solution precipitated by the addition of water, and the resulting basic nitrate thrown upon a filter, and well washed and dried; the dry salt was then mixed with black flux and the mixture ignited; the regulus of metallic bismuth thus obtained was fused several times with the addition of a small quantity of nitre, then again fused repeatedly alone, and finally poured out upon a clean porcelain plate. The mode of determination employed was that of oxydation, as the reduction of the oxyd by means of hydrogen takes place with difficulty and at a temperature at which some of the oxyd is volatilized. A known weight of the metal was dissolved in pure nitric acid, the solution evaporated to dryness and ignited, and the resulting oxyd weighed. For the precautions used to prevent loss by the mechanical transfer of small portions of the solution, and other causes, we must refer to the original memoir. As a mean of eight experiments nearly agreeing with each other, it was found that 100 parts of oxyd of bismuth contain

Bismuth, ...	89·655
Oxygen, ...	10·345

from which the equivalent of bismuth is found to be 2599·95, which of course is sufficiently nearly represented by the round number 2600. The old equivalent determined by Lagerhjelm, 2660·75, is consequently much too high, and bismuth must be placed among those elements whose equivalents are exact multiples of that of hydrogen, $2600 = 12{\cdot}5 \times 208$. —*Pogg. Ann.*, 1851, 2, 303.

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Hydruret of ethyl,	(C_4H_5, H) - -	17·90
Olefiant gas, -	(C_4H_4) - -	14·34

The decomposition of the iodid in the presence of mercury may therefore be represented by the equation, $C_4H_5I+Hg=C_4H_5+HgI$.

A small portion of the ethyl is at the same time decomposed into hydruret of ethyl and olefiant gas, $2C_4H_5=C_4H_5, H+C_4H_4$.

It appears therefore that the action of light upon the iodid of ethyl is precisely similar to its action on iodid of hydrogen, and furthermore that the decomposition which here takes place is analogous to that which the iodid of ethyl undergoes at a high temperature in presence of zinc. The presence of water was found to have no influence on the products of the decomposition of iodid of ethyl by the sun's rays. The author suggests the employment of iodid of ethyl as an actinometer or instrument to measure the intensity of the chemical action of the sun's rays; a very faint and diffuse light is sufficient to evolve a considerable volume of gas which might be easily measured and corrected for temperature, pressure, and tension of the vapor of undecomposed iodid. The author closes his most interesting memoir with an elaborate, and as it appears to us, most successful defence of his views of the nature of the hydro-carburets, C_2H_3, C_4H_6, and C_4H_5.—*Ann. der Chemie und Pharmacie*, lxxvii, 221.

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We shall confine ourselves here to a notice of those properties of the new bases which have not hitherto been fully described. Methylamine is readily prepared by distilling its chlorohydrate with twice its weight of caustic lime and collecting the gas evolved over mercury. It is a colorless gas which condenses a few degrees below 0° into a highly mobile liquid; its odor is strongly ammoniacal; in water it is more soluble than any other gas with which we are acquainted; 1 vol. of water at 12°·5 C. dissolves 1154 volumes of methylamine. It readily inflames and burns with a yellowish flame yielding water, carbonic acid, and nitrogen; with chlorohydric or carbonic acid gas it readily unites, forming white solid salts; the chlorohydrate is deliquescent. The aqueous solution of methylamine strongly resembles aqua ammonia, the gas is expelled by boiling and the solution precipitates a large number of metallic oxyds and dissolves some of them when added in excess; the salts of magnesia, manganese, iron, bismuth, chromium, uranium and tin are precipitated as by ammonia; the salts of copper and zinc are also precipitated and the precipitates are redissolved by an excess of the alkali. Nitrate of silver is completely precipitated by a solution of methylamine: the resulting oxyd is readily dissolved in the alkaline solution and when the liquid is allowed to evaporate spontaneously a black substance is formed containing carbon, hydrogen, nitrogen and silver and probably corresponding to fulminating silver: it does not explode however either by heat or by a blow. Passed through a red hot porcelain tube, methylamine yields cyanhydrate of ammonia, prussic acid, marsh gas and hydrogen. Iodine instantly acts upon a solution of methylamine and is transformed into a garnet-red powder represented by the formula $C_2H_3I_2N$, and corresponding to the so-called iodid of nitrogen which is doubtless HI_2N; it does not explode by heat. When protochlorid of platinum is heated with a solution of methylamine a green precipitate is obtained corresponding to the green salt of Magnus, and from this a new base may be obtained analogous to that known as Reiset's base and represented by the formula, $C_4H_3PtN_2$ or $NH_2(C_2H_3)+NHPt(C_2H_3)$. The oxalate of methylamine yields by dry distillation, methyloxamid, $C_2O_2, NH(C_2H_3)$ which may be regarded as oxamid in which one eq. of hydrogen is replaced by one eq. of methyl; in like manner the acid oxalate of methylamine yields methyloxamic acid, $C_2O_3+C_2O_2$, $NH(C_2H_3)$. Ethylamine is readily obtained from its chlorohydrate by distillation with lime and condenses in a cool receiver as a limpid colorless liquid which boils at 88°·7: its density at 8° is 0·6964; it possesses an ex-

The turpentine No. 1, was pure and had been rectified in a current of steam, its rotation was towards the right; No. 2, was another variety which had not been rectified and turned the plane of polarization to the left; the oil of lemon was also pure and distilled like No. 1: the author found that with pure oil of turpentine the observed angles of rotation never differed more than 5′ from the mean, whereas with oil of lemons the differences were much greater, the turpentine was therefore preferred for experiments with the galvanic current. The galvanic apparatus employed consisted of two helices of copper wire 2·3^{mm} in thickness, and weighing each about 6 lbs.; they were placed with their axes in the same straight line and had together a length of about 9 inches; in the axis of these coils was placed the tube containing the liquid to be examined. The current from a battery of about 30 pairs, (partly Grove's, partly Bunsen's and partly iron-zinc,) was made to pass through a gyrotrope, a tangents-compass, and the whole length of the coils themselves. In this manner the author studied the deflecting action of the current upon the plane of polarization in bisulphid of carbon and in oil of turpentine; the result of his investigation he gives in the following statements.

(1.) The law of Biot, according to which the rotation of the plane of polarization of any color is inversely proportional to the square of its wave length does not hold good for oil of turpentine or oil of lemon, any more than for rock-crystal, (as shown by Bloch.)

(2.) The law of Faraday, according to which the deflection of the plane of polarization is proportional to the intensity of the deflecting current, holds good for those substances, which in themselves deflect the plane of polarization, as well as for those which do not do so.

(3.) The deflection of the plane of polarization of different colors by the galvanic current is in the case of rotating as well as not-rotating substances, greater in proportion as the wave length of the color in question is less. In *rotating* substances like oil of terpentine, this deflection is proportional to the deflection produced by the substance itself upon the plane of polarization of each particular color.—*Pogg. Ann.*, 1851, *No.* 2.

2. *Physical Demonstration of the Rotation of the Earth by means of the Pendulum.*—Foucault has communicated to the Academy of Sciences an account of an experiment which has excited universal attention and interest, and which has since been frequently repeated with success. The experiment consists simply in suspending a heavy ball to a long and flexible string, and allowing the whole to vibrate freely in the manner of a pendulum; under these circumstances it will be found that the plane of vibration gradually changes its position, turning slowly from east to west. To understand what takes place in this case, it is necessary to consider first the experiment as made at the pole, and the pendulum as suspended from a point in the axis of the earth prolonged and independent of the motion of the earth itself; it is evident that in this case, as the earth moves from west to east the plane of vibration of the pendulum which is in reality fixed, will appear to move from east to west. Next suppose the pendulum suspended from a point in the axis of the earth prolonged, but attached to and moving with the earth itself, it is evident, and it may easily be demonstrated

by experiment, that the rotation of the point of suspension will not affect the plane of vibration of the pendulum, and the result will be the same as before; the plane of vibration will appear to revolve uniformly, making a complete revolution in twenty-four hours. If we transfer the point of suspension from the pole to the equator, this point will then revolve with the earth and the plane of vibration will undergo no apparent change: but if we transfer the pendulum to a point between the pole and the equator, it is clear that while the point of suspension will itself revolve uniformly with the earth, the plane of vibration of the pendulum will be carried round but less rapidly than the earth, the result will therefore be that the plane of vibration will move *with reference to the earth* from east to west, but more slowly than at the pole. Foucault finds, by two different methods, that the angular motion of the plane of vibration is equal to the angular motion of the earth in the same time multiplied by the sine of the latitude. The experiment in question has been made upon a large scale in the Pantheon at Paris, the length of the cord, and consequently the time of vibration of the pendulum allowing the apparent motion of the plane of vibration to become very distinctly evident after only a few oscillations.—*Comptes Rendus*, xxxii, p. 135. [The experiment has been repeated in this country and England.]

3. *Equivalent of Bismuth.*—Schneider has made a new determination of the equivalent of bismuth, and has obtained results which appear to be well worthy of confidence. Commercial bismuth was dissolved in pure nitric acid, the solution precipitated by the addition of water, and the resulting basic nitrate thrown upon a filter, and well washed and dried; the dry salt was then mixed with black flux and the mixture ignited; the regulus of metallic bismuth thus obtained was fused several times with the addition of a small quantity of nitre, then again fused repeatedly alone, and finally poured out upon a clean porcelain plate. The mode of determination employed was that of oxydation, as the reduction of the oxyd by means of hydrogen takes place with difficulty and at a temperature at which some of the oxyd is volatilized. A known weight of the metal was dissolved in pure nitric acid, the solution evaporated to dryness and ignited, and the resulting oxyd weighed. For the precautions used to prevent loss by the mechanical transfer of small portions of the solution, and other causes, we must refer to the original memoir. As a mean of eight experiments nearly agreeing with each other, it was found that 100 parts of oxyd of bismuth contain

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tremely penetrating ammoniacal odor and its causticity is comparable with that of potash; it changes vegetable colors from red to blue and neutralizes acids as completely as ammonia; ignited it burns with a yellowish flame. With water ethylamine is miscible in all proportions, the solution strongly resembles the solution of methylamine in its chemical properties; like a solution of caustic potash it readily dissolves alumina. Ethylamine is a stronger base than ammonia and displaces this from its saline combinations, if a large excess of a solution of ethylamine be added to salammoniac, and the whole evaporated to dryness, there remains only chlorohydrate of ethylamine. Chlorine, bromine and iodine react with a solution of ethylamine yielding compounds represented by the formulas $C_4H_5Cl_2N$, $C_4H_5Br_2N$, $C_4H_5I_2N$; the chlorine compound is decomposed by caustic potash giving acetate of potash, ammonia and chlorid of potassium,

$$C_4H_5Cl_2N+3KO+HO=KO,C_4H_3O_3+NH_3+2KCl.$$

It does not possess basic properties and is probably $NCl_2(C_4H_5)$. Ethylamine yields with protochlorid of platinum compounds analogous to those formed by methylamine. The author describes also ethyloxamid and ethylacetamid. Amylamine prepared in the same manner as the other two bases is a colorless highly fluid liquid: it boils at 95° and its density at 18° is 0·7503; it is highly caustic and possesses the odor of ammonia and at the same time of the amyl compounds; exposed to the air it attracts carbonic acid and yields a crystalline carbonate; with water it is miscible in all proportions. The author describes only the chlorohydrate, bromhydrate and amyloxamid. With regard to the theory of the constitution of the new bases, Wurtz inclines to the view of Hofmann, namely, that they are to be regarded as ammonia in which an equivalent of hydrogen is replaced by an equivalent of methyl, ethyl, or amyl; we have therefore,

Methylamine, ...	$NH_2(C_2H_3)$
Ethylamine, ...	$NH_2(C_4H_5)$
Amylamine, ...	$NH_2(C_{10}H_{11})$.

Ann. de Chimie et de Physique, xxx, 443.

7. *Constitution and products of the decomposition of Codein.*—Anderson has presented an elaborate investigation of codein and its compounds. Crystallized codein dried at 100° loses two equivalents of water and its formula is then $C_{36}H_{21}NO_6$, as first correctly determined by Gerhardt; it is a powerful base, changes vegetable reds to blue, and precipitates the oxyds of lead, copper, iron, cobalt, nickel and other metals from their saline solutions. Potash precipitates codein from its solutions but redissolves the precipitate when in great excess; ammonia also precipitates it after a short time in small transparent crystals; the author describes various salts all of which may be obtained crystallized. Moderately strong sulphuric acid converts codein into an amorphous substance which possesses the same constitution as codein itself. Nitric acid converts codein into a new base, nitrocodein, $C_{36}H_{20}(NO_4)NO_6$, which is crystalline and yields several crystalline salts: bromine gives with codein two new bases, bromcodein and tribromcodein, represented by $C_{36}H_{20}BrNO_6$ and $C_{36}H_{18}Br_3NO_6$; chlorine yields with codein a chlorinated base, $C_{36}H_{20}ClNO_6$. A concentrated solu-

tion of codein absorbs cyanogen with avidity and yields a new base dicyanocodein, $C_{40}H_{21}N_3O_6$ or $2C_2N$, $C_{36}H_{21}NO_6$. Distilled with four or five times its weight of soda-lime or potash-lime, codein yields several organic bases among which Anderson succeeded in identifying methylamine and propylamin, C_6H_9N.—*Ann. der Chemie und Pharmacie, March*, 1851, lxxvii, 341.

8. *Acetic Acid from Sea-weeds.*—STENHOUSE has found acetic acid in considerable quantity among the products of the fermentation of various species of sea-weed. Fucus nodosus yielded 1·45 per cent., Fucus vesiculosus 1·15 per cent. of the weight of the moist plant.

W. G.

9. *New Test for the Nitrites and Nitrates;* by GEORGE C. SCHAEFFER, Prof. of Chem. and Nat. Phil., Centre Coll., Danville, Ky., (Proc. Amer. Assoc., 4th meeting at New Haven, 1851, p. 403.)—Chemistry has hitherto furnished no distinctive test for the nitrites, when present in small quantities. From the supposed unfrequent occurrence of these salts, the want of such a test has never been felt.

For several years I have been engaged in a research which has led me to believe that the nitrites are of far more frequent occurrence than is commonly supposed, and that they have been mistaken for nitrates, as the usual process, with pure sulphuric acid and protosulphate of iron, will give the same reaction with both classes of salts. In order to settle the question, it was necessary to find a distinctive test, which should avoid all risk of confusion. I first tried acetic acid, which, as is well known, does not act upon the nitrates, while it decomposes nitrites. By substituting this acid for the sulphuric in the usual process, I succeeded perfectly. The test seemed even more delicate than that for the nitrates, and was more elegant in its operation.

Still the following difficulties were to be encountered. The slightest quantity of peroxyd in the sulphate gave a color with acetic acid, and injured the delicacy of the test. Moreover, the nitrites are generally either destroyed or converted into nitrates, with such readiness, that it would be almost impossible to concentrate their solutions.

At last I was led to the following process, which leaves nothing to be desired. To the solution supposed to contain a nitrite, add one or two drops of solution of yellow prussiate of potash—there should not be enough to give a perceptible tinge to the liquid. A few drops of acetic acid are then to be added, and immediately, or in a few minutes, according to the quantity of nitrite present, the liquid assumes a rich yellow tint.

As the re-agents used give nearly the same color, spontaneously, after some time, even in pure water, it is better, when testing for minute quantities, to use two similar vessels, one containing pure water, and the other the liquid under examination, to both of which the re-agents are to be added in precisely equal quantities. The vessels should be equally exposed to the light, with a sheet of white paper behind them.

With these precautions, I have found this test astonishingly delicate, in fact, ranking with those for iron, iodine, &c. Using fused nitre, I have detected the presence of one pt. in 617,000 pts. of water; a bystander wholly ignorant of the nature of the operation, pronouncing as to the color. Yet this salt contained about one-half its weight of undecomposed nitrate.

It should be remarked that the presence of a large quantity of nitre has no influence upon this test, as with pure water it gives no color. The same reaction answers also for the hyponitrates.

The next step is to convert this test into one for the nitrates. The decomposition of the nitrates of lead and mercury by boiling with excess of their respective metals, has long been known. The reaction of metals with the alkaline nitrates does not seem to have been studied. I find that nitrate of ammonia is readily decomposed in presence of metallic lead, and what seems surprising, nitrate of potash is also decomposed, though not so readily.

To test for the nitrates, we have only to agitate the slightly warmed liquid, for a few minutes, with shavings of lead, and proceed as before. By a longer digestion more of the salt would be converted into nitrite, and the color would be stronger. In estimating the delicacy of this process, I had used pure rain water, but before completing the experiments I was obliged to be absent for several days; on my return, I soon found that the water from the same cistern contained so much of nitrates and nitrites, that it could no longer be used. From the readiness with which the decomposition was effected, I presume that nitrate of ammonia was present. The interval had been marked by the occurrence of frequent and severe thunder showers.

By using distilled water, I have been able to detect the presence of one pint of nitre in about 60,000 of water, digesting with lead for only a short time. Mercury containing a minute quantity of lead, seems to answer better than lead, for a time, in the above process; but after long use it loses its effect. It will not answer to add to it any perceptible quantity of lead, as the liquid then becomes muddy on agitation.

Oxalic, tartaric, and dilute hydrochloric acids may be substituted for the acetic, except when they produce precipitates, which would destroy the clearness of the liquid.

The yellow color produced in this test is the result of a complex decomposition. Everitt's yellow salt, and red prussiate, seem to be formed, and in some cases also very minute quantities of Clayfair's nitroprussid.

II. Geology.

1. *On the Parallelism of Mountain Chains in America;* by Mr. Desor, (Proc. Boston Soc. Nat. Hist., Dec., 1850, p. 380.)—It is generally admitted that the Appalachian or Alleghany chain was raised during the deposition of the coal formation. It is consequently referred by Mr. Beaumont to his system of the Balloons, the direction of which (E. 16° S.), when transferred to Washington, becomes E. 43° 18′ N., a direction which indeed answers pretty accurately to that of the main portion of the Alleghany chain. This is also, according to Dr. C. T. Jackson, the main direction of the hills of New Hampshire and Maine. But there is besides in the Alleghanies another direction more nearly parallel to the meridian, which Professor Rogers considers as a mere deviation from the main direction, whereas Mr. Beaumont refers it to a previous upheaval, together with those ranges of hills in Massachusetts which Prof. Hitchcock has designated as the "oldest meridional system,"

and whose direction is a few degrees east of north. According to Mr. Beaumont, this latter system would not only be older than the Alleghanies, but even older than the oldest Silurian strata of North America, since it is supposed to have originated previous to the Taconic system.

Now to this system is ascribed a most conspicuous part in the constitution of the soil, not only of New England but of the whole continent, so that if true it must be of paramount importance. From Massachusetts, Mr. Beaumont traces it in a south southwest direction to the mouth of the Connecticut, and in the opposite direction across New Hampshire and the White Mountains to the sources of the Connecticut, from whence it extends across Labrador to Cape Chisley; nor is it supposed to stop here, for Mr. Beaumont follows it even beyond Davis' Strait into Greenland. The range is said to be not less extensive in the southern direction. Representing it as a great circle, starting from Amherst College in a direction south 15°, he supposes it to run parallel to the general direction of the coast of the United States from the mouth of the Hudson to Cape Hatteras. From thence it is supposed to cross the eastern portion of Cuba, the Isthmus of Panama, and then to touch Cape Guyaquil, passing a little outside of the Coast of Choco, in a direction parallel to the principal mountain chains of New Grenada.

This system, thus laid down, is considered by Mr. Beaumont as one of the most remarkable mineralogical and metalliferous zones of the globe, including all the localities whence are derived the remarkable minerals of Greenland and Labrador, the gold mines of Vermont,* Virginia, North and South Carolina, Georgia, the several gold mines of Cuba, the gold and platinum mines of Hayti, and the gold and platinum mines of Choco and the Eastern Cordilleras in New Grenada.

If we now ask for the reason why this immense belt should be so much older than any other mountain chain of this continent, we are referred to the single statement, that in New Hampshire and Vermont the primary rocks following this direction are overlaid unconformably by the strata of the Taconic system. And since the Taconic system is supposed by Mr. Beaumont to be older than the oldest Silurian, the inference on his part was but natural, that the ridges of New Hampshire, Vermont, and Massachusetts must indeed be very old. They were thus made the point of departure of this vast system, to which most of the above-mentioned localities were added merely on account of their direction or of the minerals which they contain.

Now that serious doubts are entertained as to the existence of a Taconic system in New England, especially since it has been proved by the investigations of the geologists of Canada that the slates of the Green Mountains, which were referred to the Taconic, belong in reality to the Silurian formation, the theory of Mr. Beaumont cannot longer be relied upon, being thus deprived of its principal basis. If it is once ad-

* After the reading of Mr. Desor's paper, Mr. Alger observed, that the gold found in Vermont, which he supposed was the authority for M. De Beaumont's allusion to the gold mines of that state, had proved to be of artificial origin. It was gold which had been thrown into a stream forty or fifty years since by counterfeiters, who were suddenly disturbed in their counterfeiting operations.

mitted that the Green Mountains are not Taconic but Silurian rocks, there is no reason why we should not refer them simply to the age of the Alleghanies, the more so as we have direct evidence in the raised conglomerates of Massachusetts, that at least some of the ridges of New England are not of an earlier age than the coal formation.

How far this reasoning might apply to the many other regions connected by Mr. Beaumont with this supposed oldest Meridional system, Mr. Desor was unable to say, but observed, that with all due regard for the great abilities of his illustrious teacher, he thought there was no sufficient reason for upholding any longer this peculiar system, unless it be established on better proofs.

In removing thus this so-called oldest Meridional system from its prominent place, it is not a little interesting to notice that those ranges of hills and mountains which are actually known to have been raised previous to the deposition of the oldest fossiliferous rocks, such as the primitive mountain ranges on the north bank of the St. Lawrence, the granite ranges of Lake Superior, and the iron-bearing old slates of that country are all more or less parallel to the equator. It would seem as if in these early times, there had been a prevailing disposition on the part of the earth crust to wrinkle in that direction. (We take it for granted that these old hills are the result of a shrinkage in consequence of the cooling of the earth's surface rather than a positive upheaval.) It is only at a later period that we meet with wrinkles running in the opposite direction (north and south).

2. *Lower Silurian Reptile in Canada*, (From Lyell's Anniv. Address before the Geol. Soc. of London, Feb., 1851, p. 59.)—I have not alluded in this Address to the recent discovery of the track of a quadruped imprinted on a lower silurian sandstone in North America. We are indebted to Mr. Logan, now at the head of the Government Survey in Canada, for having carefully determined the position of the rock containing it. The locality is the village of Beauharnois, on the south side of the St. Lawrence, twenty miles above Montreal. The rock, a fine-grained whitish sandstone, quarried for building, belongs to the group called the Potsdam sandstone by the New York surveyors, and lies at the base of the whole fossiliferous series of North America. The markings were first pointed out to Mr. Logan by Mr. Abraham, editor of the Montreal Gazette, who appreciated their geological importance. Assuming the Chelonian origin of these foot-prints, they constitute the earliest indication of reptile-life yet known, and are not only anterior to the most ancient memorials of fish hitherto detected, but agree in date with the first known signs of well-defined organic bodies, such as Lingulæ, met with in the same rock. Professor Owen, of the College of Surgeons, has examined a slab of the sandstone, on the upper surface of which the foot-prints are impressed, together with a plaster cast of the remainder of the continuous trail, in all 12½ feet long, brought to London by Mr. Logan; and the Hunterian Professor has had the kindness to communicate to me the following description.*

"The impressions are more numerous in regular succession than any that have been previously discovered; so that the evidence of

* R. Owen—Letter to Sir C. Lyell, March 18th, 1851.

their having been made by successive steps, afforded by this succession of corresponding prints at regular intervals, is the strongest we possess. They are in pairs, and the pairs extend in two parallel linear series with a groove midway between the two series. The outer impression of each pair is the largest, and it is a little behind the inner one. Both are short and broad, with feeble indications of divisions at their fore part. They succeed each other at intervals much shorter than that between the right and left pair.

"The median groove is well defined and slopes down more steeply at its sides than towards the bottom, at some parts of the track. I conclude from these characters that the animal which left the track was a quadruped, with the hind-feet larger and wider apart than the fore-feet; with both hind and fore-feet very short, or impeded by some other part of the animal's structure from making any but short steps; that the fore and hind limbs were near each other, but that the limbs of the right and those of the left side were wide apart: consequently, that the animal had a short but broad trunk, supported on limbs either short or capable only of short steps; and that its feet were rounded and stumpy, without long claws.

"As to the median impression, that may be due either to a thick heavy tail, or to the under surface of the trunk, dragged along the ground. The shape of the body and the nature of the limbs, indicated by the above-described characters of the steps, accord best with those of the land or freshwater tortoises, and the median groove might have been scooped out by the hard surface of a prominent plastron.

"The disproportion in the size of the fore and hind-feet is such as we find in some existing Terrapenes, e. g., the *Emys geographica*."

III. Zoology.

1. *On the Classification of the Cancroidea;* by James D. Dana.—The Cancroidea (or Crustacea Cyclometopa), like the Maioidea, are characterized by having, (1) the branchiæ 9 in number, 7 of which lie so as to form the exterior of the branchial pyramid; (2) the efferent passage from the branchial cavity passing over the lateral portions of the palate; (3) the male genital orifices situated in the base of the posterior legs and covered by the abdomen; (3) the male abdomen not narrower at base than the corresponding part of the sternum; (4) the buccal area subquadrate, and the 4th joint of the outer maxillipeds articulated with the 3d by its inner angle. The Telphusidæ have these characters, and may be considered true Cancroidea, though approximating to the Grapsoidea in the large vacant space in the branchial cavity, and having some peculiarities in the branchiæ fitting them for freshwater life.

The Corystes group also partake of the Cancroid character; yet they diverge from it, in the large outer antennæ more or less hairy, and both in this respect and in form, they approach the Hippa group, and thus have a much lower position in the series than the Cancroidea. They have no true relation in the character of the buccal area and efferent canal to the Leucosia group.

The genera Acanthocyclus and Corystoides (of Lucas) have the genital orifices, sternum and abdomen, and outer maxillipeds of the Cancroidea and Corystoidea; but the branchiæ (in Acanthocyclus at least)

are less numerous, as in the Grapsoidea. The outer antennæ are obsolete, and the inner in Corystoides have no fossettes. They are therefore genera of low grade, at the foot of the Cancroidea, and approach closely in rank to the Corystoidea.

Our grand divisions of the Cancroidea are hence,

1. Cancrinea, or Cancroidea Typica.
2. Telphusinea or Cancroidea Grapsidica.
3. Cyclinea, or Cancroidea Corystidica.

The character of the efferent passage or canal, separating the Leucosoid Crustacea or Oxystomata, is the most striking among the Brachyura. While, in all other species, this passage passes over the outer portions of the palate or prælabial area, in these, it passes over the medial portions, and terminates at the middle of the front margin of the buccal area which is therefore elongated, giving the area a triangulate outline: the character of this passage and not the form of the area is the important character of the Leucosoidea. The inner branch of the 1st pair of maxillipeds is modified to correspond, as it covers (more or less perfectly) in this and all the Brachyura the efferent passage.

The efferent passage, which affords the striking character alluded to, has its different degrees of perfection among the Cancroidea. In a large number of genera, the waters wash over the palate without any confining ridge: but in others there is a distinct ridge, running longitudinally, near the middle of either lateral half of the palate, and terminating at the front margin of the buccal area. This ridge is prominent in Eriphia, Ruppellia, Ozius, Pilumnoides, Melia (as the writer has observed) and some other genera, and is also distinct in Pilumnus. It is wanting in Cancer, Xantho, and the allied, or if a trace is to be observed, (as in Menippe Rumphii and some other species,) it does not reach to the front margin of the buccal area. We have in this character, therefore, an important distinction separating the non-natatory Cancrinea into two groups, the Cancridæ and the Eriphidæ. Mere breadth of carapax alone is of very little value as a characteristic: Xantho passes by its allied genera into species but little broader than long, and so with Chlorodius.

Among the swimming species, a large part, as detected by De Haan, have a small lobe attached to the inner margin of the inner branch of the 1st maxillipeds: while others, as Platyonychus and the allied have no such lobe and approximate somewhat to the Corystoidea, although not properly, as we think, of that group.

The species of Lupa and Thalamita have a ridge upon the palate either side bounding the efferent passage; but there is one exception in *Lupa cribraria*, which species consequently must pertain to a distinct group from the other Lupas.

In these brief remarks on the classification of the Cancroidea, we leave much to be gathered from the following synopsis. But a few words should be offered on the genera of De Haan and Edwards; partly because the two are to some extent in conflict, and partly because several of those of De Haan are of unessential importance. The publication of the first fascicle of De Haan's Crustacea of the Fauna Japonica in 1833, preceded Edwards by a year, but the descriptions of his genera were so concise and imperfect that it was not possible for any one to have recognized them all.

Ruppellia of Edwards, and ***Eudora*** of De Haan, have the same typical species. But De Haan neglected to observe in the type the important peculiarity of the orbit, (its being wholly closed within so as to exclude the base of the outer antennæ, a peculiarity found in no Brachyura except a few of the Eriphidæ,) and hence his genus includes, according to his own use of it, some Xanthoid species. The two names are by no means synonyms; and adopting the group as laid down by Edwards, we are forced to adopt his generic name. Modifications to some extent may be made in accepted genera, and this we have attempted in some instances below, but not the complete perversion that would happen by giving De Haan's name to Edwards's genus.

De Haan has not recognized the distinction between the pointed and spoon-shape figures as a generic characteristic, and this makes some difficulty in substituting his names for those of Edwards, where the groups are otherwise similar. This characteristic was first employed by Leach and subsequently by Edwards. The genera of the two kinds often graduate into one another: but the parallel relation between the series is best shown by retaining them apart in separate subfamilies. Between our Xanthinæ and Chlorodinæ there is nearly a perfect parallelism. De Haan's species of the genus Xantho are in part Chlorodii.

De Haan has multiplied much the genera of swimming Crabs, by subdividing Lupa and Thalamita. This has partly arisen from an unwarranted reliance for the characteristic on the form of the 3d joint of the outer maxillipeds, as well as on that of the inner branch of the 1st maxillipeds.

In a former paper it was observed that the 3d joint of the outer maxillipeds may undergo great variations in proportion in the same genus. This is well illustrated among the Portunidæ. Amphitrite of De Haan (a subdivision of Lupa) is described as having this joint *short and oblique*. But in species of true Amphitrite, it varies from this form to a form unusually oblong. Again he makes Neptunus and Achelous differ from Amphitrite in having this joint more oblong, the reverse of which is actually the fact among many of the species examined by the writer. So Thalamita is characterized by having this same joint short, when in fact it is sometimes longer than broad. The form in one species (T. integra, *D.*) scarcely differs in relative length or obliquity from that of Lupa dicantha. Again *Oceanus* (Thalamita crucifera of Edwards) is said to have the inner branch of the 1st maxillipeds three-lobed, and *Thalamita*, as having the inner margin unidentate. The latter has the inner lobe as in Oceanus, and this makes the one tooth; the margin outside of this lobe or tooth, is straight at top in some species (T. crassimana and crenata), but excavate in others, becoming even deep and angulate in *Th. integra*, a species very near *admetus* in form and general characters. There is thus a gradual transition to the form in Oceanus. Such variations in this margin are therefore unimportant, as many other cases illustrate.

Our grand divisions are named after the larger to which they approximate. This plan might be carried farther with much profit. Thus among the five families of Cancrinea—the Cancridæ, are the *Cancrinea Typica;* the Eriphidæ, are the *Cancrinea Grapsidica*, for in the ridges of the palate as well as form they approximate to Grapsus;

the Portunidæ, are the *Cancrinea Typica Natatoria;* the Platyonychidæ, the *Cancrinea Corystidica Natatoria;* the Podopthalmidæ, the *Cancrinea Grapsidica Natatoria.* Again, among the subfamilies of Cancridæ, the Cancrinæ, are the *Cancridæ Corystidicæ;* the Xanthinæ and Chlorodinæ, the *Cancridæ Typicæ.*

The following is a synopsis of the known genera of Cancroidea.—

Legio I. CANCRINEA, vel CANCROIDEA TYPICA.

Fam. I. CANCRIDÆ.

Pedes postici gressorii. Ramus maxillipedis 1mi internus simplex. Palatum (vel area prælabiata) colliculo ad marginem anticum producto non divisum. Carapax sæpius late transversus, interdum angustus.

1. CANCRINÆ.—Antennæ internæ plus minusve longitudinales. Frons interorbitalis perangustus. Digiti acuminati.
   - G. 1. Cancer,* *Leach.*—Pars antennæ externæ mobilis hiatu orbitæ omnino exclusa. Carapax latissimus.
   - G. 2. Pirimela, *Leach.*—Pars antennæ externæ mobilis hiatu orbitæ non exclusa. Carapax perangustus.

2. XANTHINÆ.—Antennæ internæ plus minusve transversæ. Antennæ externæ basi firmè infixæ, parte mobili hiatu orbitæ non exclusâ. Frons interorbitalis latior. Digiti acuminati.

   1. *Regio carapacis postica convexa. Orbita hiatu externo non interrupta.*
      - G. 1. Atergatis, *De Haan.*†—Margo antero-lateralis postero-laterali longior. Pedes 8 postici compressi, cristati.
      - G. 2. Carpilius, *Leach, De Haan.*—Margo antero-lateralis postero-laterali longior. Frons sæpissime bene 4-lobatus. Ramus maxillipedis 1mi internus lobato-furcatus. Pedes 8 postici nudi, subcylindrici, non cristati.
      - G. 3. Liomera, *Dana.*‡—Frons leviter 2-lobatus aut rectiusculus. Margo antero-lateralis postero-laterali non brevior. Ramus maxillipedis 1mi internus non lobatus. Pedes 8 postici nudi, subcylindrici, non cristati.
      - G. 4. Liagora, *De Haan.*§—Margo antero-lateralis postero-laterali brevior. Frons leviter 2-lobatus aut rectiusculus. Pedes nudi, tarsis exceptis. Ramus maxillipedis 1mi internus non lobatus.

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* *Platycarcinus*, Milne Edwards, Crust. i, 412.

† Faun. Japon. 17.—*Cancer* of Edwards, Crust. i, 372; and *Platypodia* of Bell, Zool. Trans. i, 335, 1835.

‡ Includes *Carpilius cinctimanus* of White, Crust. Voy. Samarang, 37, pl. 7, f. 4. The lobato-furcate form of the inner branch of the 1st pair of maxillipeds in Carpilius maculatus and the allied, is so peculiar, as shown by De Haan, that it must be admitted as a generic distinction. The true Carpilii have a strongly 4-lobed margin to the front, though the front is sometimes so bent downward that the lobes are not seen in a vertical view, though distinct in a front view.

§ Faun. Japon. 19.

2. *Regio carapacis postica transversim non convexa.*

a. Caxapax versus margines frontalem antero-lateralemque curvatim declivis.

G. 5. ACTÆA, *De Haan*,* *Dana.*—Margo postero-lateralis brevis, sæpius concavus. Orbita hiatu externo non interrupta.

b. Carapax versus margines frontalem antero-lateralemque parce declivis.

α *Orbita hiatu externo non interrupta.*

G. 6. XANTHO, *Leach.*—Margo antero-lateralis postero-laterali longior. Articulus antennæ externæ 1mus oblongus, frontem bene attingens, articulo sequente e apicis medio articuli 1mi orto.

G. 7. EUXANTHUS, *Dana.*—*Xantho* formâ similis: articulus antennæ externæ 1mus hiatum ad summum implens, articulo sequente e latere excavato apicis orto.

G. 8. PARAXANTHUS, *Lucas.*†—*Xantho* formâ similis: articulus antennæ externæ 1mus abbreviatus processum frontis oblongum attingens tantum. Abdomen *maris* 5-articulatum.

G. 9. MENIPPE, *De Haan.*‡—Margo antero-lateralis postero-laterali brevior. Articulus antennæ externæ brevis nec frontem nec frontis processum attingens. Abdomen maris 7-articulatum.

β *Orbita hiatu externo interrupta, infra integra.*

G. 10. PANOPÆUS, *Edwards.*—Margo antero-lateralis tenuis, postero-laterali sæpius brevior, ad orbitæ angulum externum directus.

γ *Orbita infra extusque tribus dentibus instructa, uno externo, duobus inferioribus.*

G. 11. MEDÆUS, *Dana.*—Angustus, paulo transversus, [nudus,] fronte sat brevi. Margo antero-lateralis sub orbitâ productus. Abdomen *maris* 5-articulatum, segmento ultimo brevi. Pedes antici crassi, iis *Xanthi* similes.

G. 12. HALIMEDE, *De Haan.*§—Angustus, parce transversus, [villosus,] fronte breviore. Abdomen maris 7-articulatum, segmento ultimo valde elongato. Pedes antici crassi, iis *Xanthi* similes.—An *Pilumnis* propinquior?

3. CHLORODINÆ.—Antennæ internæ transversæ. Antennæ externæ basi firmè infixæ, parte mobili hiatu orbitæ raro exclusâ. Frons interorbitalis latior. Digiti instar cochlearis excavati.—Quoad genera, Xanthinæ et Chlorodinæ ferme parallelæ.

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* Faun. Japon. 18.

† Crust. D'Orb. S. Am., 18. We see no sufficient character for sustaining this genus, excepting the short basal joint of the outer antennæ.

‡ Faun. Jap. 21.—*Pseudocarcinus* of Edwards, Crust. i, 407.—*Pelæus*, Eydoux and Soulevet, Voy. de la Bonite. *Pelæus armatus* is the name given to a Sandwich Island species figured in the plates of the Bonite, but not yet described.

§ Faun. Japon. 35. Our *Medæus* has nearly the outline of Halimede, but is naked and very deeply areolate. It is a Xantho in nearly all its characters, though narrow, and having the orbit below deeply divided. On this account, I have introduced Halimede, which resembles our genus in form, in this place, not having had an opportunity to study its characters from specimens.

1. *Hiatus orbitæ internus processu basis antennæ externæ occupatus, articulum 2dum occludens.*

G. 1. Etisus, *Leach.**

2. *Hiatus orbitæ internus basi antennæ externæ occupatus, articulo 2do non occluso.*

1. Regio carapacis postica convexa.

G. 2. Carpilodes, *Dana.*—Carapax latus, nudus, margine antero-laterali crassè rotundato. Pedes 8 postici subcylindrici, nudi. *Liomeræ* habitu similis.

G. 3. Zozymus, *Leach.*†—Carapax mediocriter latus, margine antero-laterali tenui. Pedes 8 postici valde compressi, cristati aut subcristati. *Atergati* habitu similis.

2. Regio carapacis postica fere plana.

a. Carapax versus margines frontalem antero-lateralemque curvatim declivis.

G. 4. Actæodes, *Dana.*‡—Pedes 8 postici non cristati. *Actææ* aspectu similis. Articulus maxillipedis externi 3tius apicem vix excavatus.

G. 5. Daïra, *De Haan.*§—Pedes 8 postici non cristati. Articulus maxillipedis externi 3tius apice valde emarginatus.

b. Carapax versus margines frontalem antero-lateralemque vix declivis.

G. 6. Chlorodius, *Leach.*‖—Carapax plus minusve transversus Articulus antennæ externæ 1mus oblongus frontem bene attingens. Articulus maxillipedis externi 3tius subrectangulatus. *Xantho* aspectu similis.

G. 7. Pilodius, *Dana.*—Carapax paulo transversus. Articulus antennæ externæ abbreviatus, processum frontis oblongum attingens tantum. *Paraxantho* aspectu similis.

G. 8. Cyclodius, *Dana.*—Carapax parce transversus. Articulus antennæ externæ oblongus frontem bene attingens. Articulus maxillipedis externi 3tius triangulatus, latere interiore brevissimo.

G. 9. Cymo, *De Haan.*¶—Carapax non transversus, fere orbiculatus, disciformis. Antennis *Chlorodio* affinis.

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* Part of the species (the typical) have the arm long projecting, and a broad form somewhat like Cancer. Another part, quite different in habit, have a short arm as in Actæodes, and graduate into Actæodes. The latter may well be named Etisodes.

† *Zozymus* of Leach and *Ægle* of De Haan have the same species as type, the *Z. æneus*, and De Haan makes the cristate character of the 8 posterior legs a generic character. We follow him in this respect, though adding the character dependent on the spoon-shape of the fingers, as done by Leach.

‡ Includes *Zozymus tomentosus* and the allied, in which the 8 posterior legs are not cristate. The species are closely like Actææ except in the fingers.

§ Faun. Japon. 18; *Lagostoma*, Edwards, Crust. i, 386.

‖ *Chlorodius* of De Haan (F. Jap. 13) of subsequent date, is synonymous with *Atelecyclus* of Leach.

¶ Faun. Japon. 22.

4. POLYDECTINÆ.—Antennæ internæ transversæ. Antennæ externæ basi solutæ, liberæ.—An *Pilumnis* propinquior?

G. Polydectus, *Edw.**—Orbita dentibus tribus infra instructa. Manus elongata, digitis prælongis, attenuatis, uncinatis, cum dentibus tenuiter spinuliformibus sæpe armatis.

Fam. II. ERIPHIDÆ.

Pedibus maxillipedeque 1mo *Cancridis* affinis. Palatum colliculo usque ad marginem anticum producto utrinque divisum. Carapax sæpius angustus, interdum latus, latitudine ante-mediana sæpissimè majore, oculis remotis.

1. ŒTHRINÆ.—Carapax transversus, lateribus valde dilatatus et rotundatus. Antennæ internæ fere longitudinales.

G. 1. Œthra, *Leach.*

2. OZINÆ.—Carapax plus minusve transversus. Digiti acuminati. Antennæ internæ transversæ. Orbita hiatu interno basi antennæ occupato instructa. Abdomen *maris* 7-articulatum.

1. *Articulus antennæ externæ 1mus frontem bene attingens.*

G. 1. Galene, *De Haan.*†—Carapax transversus, longitudinaliter multo convexus, antice declivis.—An *Potamiæ* propinquior?

G. 2. Ozius, *Leach.*—Carapax transversus, latus, fere planus.

2. *Articulus antennæ externæ 1mus frontem non attingens.*

G. 3. Pseudozius, *Dana.*‡—Carapax transversus, fere planus, latior, margine antero-laterali breviore.

G. 4. Pilumnus, *Leach.*—Carapax angustus, parce transversus, sæpius convexus, margine antero-laterali breviore.

G. 5. Pilumnoides, *Edw.* et *Lucas.*§—Carapax angustus, parce transversus, valde convexus, margine antero-laterali longiore, bene arcuato, super carapacem postice incurvato.

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* This genus is very peculiar in the hand: both fingers are long styliform and very slender, with incurved apices, and hardly touching except at tips, and when dentate the teeth are delicate spines on the inner margin; moreover, the part of the hand anterior to the fingers is quite short. A species collected by the writer is closely like the *P. cupulifer* in most of its characters. The form of the hand is very unlike anything among other Cancroidea; and Halimede which has been supposed to be near Polydectus, has (like Medæus) the ordinary form, like that in Xantho.

The genus *Iphiculus* of White (Crust. Voy. Samarang, 57, pl. 13, f. 5), has the general characters of our Polydectus—the same villous coat, similar fingers, even to the spiniform dentation of the fingers, and other resemblances; and we suspect although a broader species, that his *I. spongiosus* is a true *Polydectus.*

The specimen of the Polydectus, from which a description with a colored drawing was taken by me while it was living, is not now found in our collections, and I have not therefore been able to ascertain the character of the prælabial plate and thus assure myself whether the species are related to the Eriphidæ or not. It is very possible that the true place is after Ozinæ.

† Faun. Japon. 19.

‡ Near Pseudocarcinus, from which it differs in the ridge on the prælabial plate, as well as in its flatter form.

§ Crust. D'Orb. S. Am., 21.

G. 6. Melia, *Latr.*—Carapax subquadratus, fere planus, fronte lato, oculis versus angulos insitis. Pedes toti graciles. Basis antennæ externæ cylindricus.

An genus sequens hîc pertinet?

Acanthodes, *De Haan.**—Carapax angustus, *Pilumno* formâ affinis, spinis grandibus anticè armatus. Pedes spinosi.—Species *Acanthodes armatus* Haanii magnitudine portentosus.

3. ACTUMNINÆ.—Orbitâ *Ozinis* similis. Digiti instar cochlearis excavati.

G. Actumnus, *Dana.*†—Carapax paulo transversus, valde convexus, antice lateraliterque curvatim declivis. Articulus antennæ externæ 1mus processum frontis attingens tantum.

4. ERIPHINÆ.—Orbita infra bene clausa, hiatu interno carens, articulo antennæ e orbitâ omnino excluso. Carapax sive paulo transversus sive subquadratus.

G. 1. Ruppellia, *Edw.*—Carapax latior. Antennæ pars mobilis externæ orbitâ paululum remota. Articulus maxillipedis externi 3tius paulo transversus.

G. 2. Eriphia, *Latr.*—Carapax angustus, convexus, fronte sæpius valde declivi. Antennæ pars mobilis externæ orbitâ longe remota. Articulus maxillipedis externi 3tius paulo transversus.

G. 3. Domæcius, *Souleyet.*‡—*Ruppelliæ* formâ antennisque externis affinis. Articulus maxillipedis externi 3tius valde transversus, brevissimus, epistomam tegens.

G. 4. Trapezia, *Latr.*—Carapax subquadratus, planus, glaber, fronte horizontalis, leviter 6–8-dentatus, aut sinuosus, lateribus longitudinalis. Tarsi non unguiculati, minute spinulosi. Brachium ultra carapacem longe exsertum.

G. 5. Tetralia, *Dana.*§—Carapax aspectu *Trapeziæ* affinis. Frons horizontalis, rectiusculus, subtilissimè denticulatus. Tarsi breviter unguiculati. Brachium ultra carapacem paulo exsertum.

G. 6. Quadrella, *Dana.*—Carapax subquadratus, paulo convexus, lævis, fronte horizontalis, 6-spinoso-dentatus. Tarsi unguiculati. Brachium ultra carapacem longe exsertum.

Fam. III. PORTUNIDÆ.

Pedes postici natatorii, tarso laminato. Ramus maxillipedis 1mi internus lobo interno instructus. Palatum colliculo utrinque sæpissime divisum. Corpus sive latum sive angustum, oculis sat brevibus.

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* Faun. Japon. 20.

† Very near Actæa, but the prælabial plate or palate is strongly divided by a ridge either side. Besides, the form is much narrower and more convex than in the Actææ, being subglobose above.

‡ Voy. of the Bonite; also, "Voy. au Pole Sud," under D'Urville, in the Astrolabe and Zélée, plate 6, figs. 3-7, by Hombron and Jacquinot.

§ This Journal, [2] xi, 223.

1. LUPINÆ.—Sutura sterni mediana segmenta tria intersecans. Palati colliculi prominentes.

1. *Pars antennæ externæ mobilis hiatu orbitæ non occlusa, orbitâ jacendo aptata.*

G. 1. Scylla, *De Haan.**—Valde latus et crassus, marginibus anterioribus simul sumtis bene arcuatus, antero-laterali longiore quam postero-lateralis. Pedes antici breviores, crassissimi, manu valde tumidâ, non angulatâ vel prismaticâ.

G. 2. Lupa, *Leach.*†—Valde latus, marginibus anterioribus totis simul sumtis bene arcuatus. Manus elongatè trigona aut prismatica, costata.

G. 3. Amphitrite, *De Haan*,‡ *Dana.*—Angustior. Margines frontalis antero-lateralisque angulo convenientes, antero-laterali raro breviore quam postero-lateralis. Manus elongata, prismatica. Basis antennæ externæ crassus, hiatu orbitæ parce angustior.

G. 4. Carupa, *Dana.*—Transversus. Margines frontalis antero-lateralisque angulo convenientes, fronte recto, emarginato. Basis antennæ externæ subcylindricus, hiatu orbitæ multo angustior.

2. *Pars antennæ externæ mobilis hiatu orbitæ omnino per basis processum occlusa, orbitâ plus minusve remota.*

G. 5. Thalamita, *Latr.*—Latus. Frons dimidio latitudinis carapacis longior; margo antero-lateralis longitudinalis. Articulus antennæ externæ 1mus prælongus, 2dus orbitâ remotissimus. Pedes antici longi, manu elongatâ.

G. 6. Charybdis, *De Haan*, *Dana.*§—Angustior. Frons dimidio latitudinis carapacis brevior; margo antero-lateralis obliquus. Articulus antennæ externæ 1mus paulo oblongus, 2dus orbitâ paulo remotus. Pedes antici longi, manu elongatâ.

G. 7. Lissocarcinus, *White.*‖—Suborbiculatus, lævis, subporcellanus. Articulus antennæ externæ 1mus brevis, fere longitudinalis, articulo sequente orbitâ parce remoto. Pedes nudi; antici breves, brachio ultra carapacem vix saliente, manu perbrevi.

2. ARENÆINÆ.—Sutura sterni mediana segmenta tria intersecans. Palatum colliculo utrinque non divisum. Ramus maxillipedis 1mi internus ad apicem late transversim triangulatus lineamque medianam fere attingens.

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* Faun. Japon. 11.

† *Neptunus*, *Pontus* and *Achelous* of De Haan, (Faun. Japon., 8, 9,) the distinctions between which genera appear not to be sustained.

‡ Faun. Japon. 8. Includes, as here adopted, the Lupa of De Haan, which division he restricts to the *Lupa forceps* (Edw. Crust. i, 456). The *Lupocyclus* of Adams and White, (Crust. Voy. Samarang, 47, pl. 12, f. 4,) appears to be identical with Amphitrite.

§ Fauna Japon. 10. Includes both *Charybdis* and *Oceanus* of De Haan, which divisions shade into one another by imperceptible gradations, and are not distinguished by any important characters. Corresponds to the "Thalamites Hexagonales" of Edwards.

‖ Crust. Voy. Samarang, 45. We have taken the generic characters from a species collected by us, in connection with the description by White.

G. Arenæus, *Dana.*—*Lupæ* affinis. Carapax valde latus, antice arcuatus. Pars antennæ externæ mobilis hiatu orbitæ insita. Manus prismatica.*

3. PORTUNINÆ.—Sutura sterni mediana segmenta duo intersecans. Colliculi palati sæpius obsoleti.

G. Portunus, *Fabr.*—Angustus, margine antero-laterali breviore quam postero-lateralis.

Fam. IV. PLATYONYCHIDÆ.

Pedes postici natatorii, tarso laminato. Ramus maxillipedis 1mi internus lobo interno non instructus. Palatum colliculo utrinque non divisum. Corpus angustum.

G. 1. Carcinus, *Leach.*†—Pedes postici male natatorii, tarso angustè lanceolato. Carapax parce transversus.

G. 2. Portumnus, *Leach.*—Pedes 5ti natatorii tantum, tarso lanceolato, acuto. Carapax non latior quam longior.

G. 3. Platyonychus, *Latr.*‡—Pedes 5ti natatorii tantum, tarso lato, elliptico. Carapax latior quam longior.

G. 4. Polybius, *Leach.*—Pedes 2di, 3tii, 4ti, 5ti toti natatorii, tarsis late lanceolatis.

Fam. V. PODOPHTHALMIDÆ.

Pedes postici natatorii, tarso laminato. Ramus maxillipedis 1mi internus lobo interno instructus. Corpus latum, antice valde transversum, orbitis oculisque longissimis.

G. Podophthalmus, *Lamarck.*

Legio II. TELPHUSINEA, vel CANCROIDEA GRAPSIDICA.

Fam. I. TELPHUSIDÆ.

Carapax subquadratus aut orbiculato-quadratus. Palatum colliculo utrinque sæpius divisum. [Species Eriphiis paulo affines.]

G. 1. Telphusa, *Latr.*—Articulus maxillipedis externi 3tius subquadratus, 2dus oblongus. Carapax subquadratus.

G. 2. Trichodactylus, *Latr.*—Articulus maxillipedis externi 3tius subtriangulatus, 2dus oblongus.

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* This genus is instituted for the Lupa cribraria, which differs from the other Lupas in the characters stated. This species occurs in the shallow waters off a sand beach.

† Xaiva of M'Leay (Smith's Illust. Zool. S. Africa) is described as near Carcinus. The narrow form is the same; the antero-lateral margin 1-dentate and shorter than the postero-lateral; the tarsus of the 5th pair of legs wider than in Carcinus; the 3d joint of the outer maxillipeds subquadrate and carinate at base, with the inner margin emarginated for the next joint just above its middle, a form which occurs in Platyonychus.

‡ *Anisopus* of De Haan, Faun. Japon.

G. 3. VALDIVIA, *White.**—Articulus maxillipedis externi 2dus brevior quam latior, 3tius longior quam latior.

G. 4. POTAMIA, *Latr.*—Articulus maxillipedis externi 3tius apice subtriangulatus anguloque apicali 4tum gerens. Palatum colliculo utrinque bene partitum.

An hîc pertinet genus *Galene* Haanii ?†

LEGIO III. CYCLINEA, VEL CANCROIDEA CORYSTIDICA.

Pedibus maxillipedeque 1mo CANCRIDIS affinis. Palatum colliculo utrinque non divisum. Antennæ externæ obsoletæ. Carapax angustus, suborbiculatus. Branchiæ numero septem.

G. 1. ACANTHOCYCLUS, *Lucas.*‡—Carapax orbiculatus. Pedes longitudine mediocres, tarso uncinato.

G. 2. CORYSTOIDES, *Lucas.*§—Carapax oblongus, ellipticus. Pedes longiores, tarso styliformi, longo. Antennæ internæ fossis carentes.

2. ***Additional note to the Remarks on the Classification of the Maioidea;*** by JAMES D. DANA.‖—The following genus by Kröyer¶ should be added to the synopsis given in the last number of this Journal. It appears to belong to the subfamily Inachinæ, and is classed near Inachus by its author. The species on which the genus is founded is the *Cancer phalangium* of Fabricius, Faun. Groenl. n. 214, and his *Cancer Opilio* in Det danske Vid. Selsk. Skr. nye Saml. iii, 180. It is from Greenland. Kröyer gives the following generic characters:—

G. CHIONŒCETES.—Cephalothorax depressus, subtriangularis, eadem fere longitudine ac latitudine, antice truncatus, fronte lata rostroque horizontali, bifido, brevissimo. Pedes 2di paris duplicem cephalothoracis longitudinem superantes, triplicem vero non attingentes; pedes 1mi paris 2dis tertiisque breviores, cephalothorace vero longiores (interdum duplo); chelis acuminatis, falcatis; *pedes 2di, 3tii, 4tique paris compressi*, 5ti paris subcylindrici. 3tius pedum maxillarium externorum articulus fere quadratus eadem pæne longitudine ac latitudine; 4tus articulus angulo interno tertii adnexus; oculi crassi, in orbitam retractiles; pars antennarum externarum terminalis mobilis brevissima. Abdomen sex constat articulis.—The name Chionœcetes is from *χιων*, *nix*, and *οικητης*, *incola*.

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* Ann. and Mag. Nat. Hist., xx, (1847,) 206.

† See page 127, where it is placed with the Ozinæ. The branchial cavity is very large, as in Potamia, and contains outside of the branchiæ a large open space. The shell of a specimen from the Sandwich Ids. closely like the *G. natalensis* of Krauss, has the appearance of a fresh-water or land species, the texture being less calcareous than in most marine species. The specimen was not collected by the writer, and its exact habitat is not known. Krauss's species occurred under stones on the shores at the mouth of a river in South Africa.

‡ Crust. D'Orbign. S. Am. 29, pl. 15,

§ Crust. D'Orbign. S. Am. 31, pl. 16.

‖ Last volume of this Journal, p. 425.

¶ Tidskrift, ii, 249.

3. *Microscopic examination of Soundings, made by the U. S. Coast Survey off the Atlantic Coast of the United States;* by Prof. J. W. BAILEY, (16 pp. 4to. with a plate; from vol. ii, of the Smithsonian Contributions to Knowledge.)—After special details with referenee to the character of the material in each case of sounding, Prof. Bailey gives the following very important statements as the general results of the examinations.

1st. The most remarkable fact determined by the examination of the above mentioned soundings is, that in all the deep soundings, from that of fifty-one fathoms S. E. of Montauk Point, to that of ninety fathoms S. E. of Cape Henlopen, there is a truly wonderful development of minute organic forms, consisting chiefly of Polythalamia, which occur in an abundance rivalling those vast accumulations of analogous forms constituting the marls under the city of Charleston, S. C.

2d. While there is a general resemblance between the species found in all the *deep* soundings above mentioned, the same species of Polythalamia occurring with few exceptions at each locality, yet each place has its predominant species; thus in the most southerly soundings, (H, No. 1, 90 fathoms,) there occurs a much greater number of Globigerina than in any of the others; while Textilaria atlantica, although present, is by no means so abundant as in "G, No. 8, 89 fathoms."

3d. Infusoria, as well as Polythalamia, occur in the deep soundings; but the infusoria are few in number, and consist of Coscinodisci, Gallionella sulcata, and other species, which probably swim freely in the ocean; while none of the littoral parasitic species, such as Achnanthes, Isthmia, Biddulphia, Striatella, and Synedra are found.

4th. It is worthy of notice that in the deep soundings not a single specimen was found of Polythalamia belonging to the Plicatilia of Ehrenberg, (Agathistiques of D'Orbigny,) while a number of these forms were found in the shallow soundings, and they are well known to occur in vast quantities around the shores of Florida and the West India Islands. This group of Polythalamia appears to have been created after the deposition of the chalk formation, in which no trace of such forms occurs, while they are very abundant in the tertiary deposites. Their entire absence in the deep soundings, where vast numbers of other Polythalamia occur, and their presence in littoral deposits, would seem to indicate that for their abundant development comparatively shallow seas are necessary; thus affording additional evidence of difference in the depths of the seas from which the cretaceous and tertiary beds were deposited.

5th. The deep soundings were all from localities which are more or less under the influence of the Gulf stream, and it is not improbable that the high temperature of the waters along the oceanic current may be the cause of immense development of organic life, making its path, as is shown by the soundings, a perfect milky way of Polythalamia forms. The deposits under Charleston may have been produced under the similar influence of an ancient gulf stream.

6th. From the presence of such great numbers of Polythalamia in the deep soundings, there results a very large proportion of calcareous matter, thus presenting a striking difference between them and the quartzose and felspathic sands nearer shore.

7th. The littoral sands obtained in shallow soundings at first view appear to afford little promise of affording any Infusoria. But notwithstanding their coarse, and, in some cases, even gravelly nature, they all yield by levigation a considerable number of silicious Infusoria, which in variety and abundance exceed those found in the deep soundings.

8th. None of the soundings present anything resembling the vast accumulations of Infusoria which occur in the Miocene infusorial marls of Virginia and Maryland: and, indeed, I have never found, even in estuaries, any recent deposit at all resembling the fossil ones, in abundance and variety of species, with the exception of the mud of a small creek opening into the Atlantic near Rockaway, Long Island.

9th. The occurrence of the pebble of limestone with encrinal plates in the gravel of F, No. 10, S. E. of Little Egg Harbor, is of some interest, as the nearest beds from which it could have come are the Silurian formations of Pennsylvania or northern New Jersey. It indicates a transportation of drift to a considerable distance sea-ward.

10th. In addition to the quartzose grains in the soundings, fragments of feldspar and hornblende (recognizable under the microscope by their cleavage planes and color) are found. The quartz, however, predominates, its grains being sharp and angular in the deep soundings, and often rounded or even polished in the shallow ones.

IV. Astronomy.

1. *On the new Ring of Saturn;* by W. C. Bond, Esq., Director of the Observatory of Harvard University, (Ast. Jour., vol. ii, No. 1, May, 1851.)—I had intended not to have made any communication on the subject of the new interior ring of *Saturn*, until an engraving had been prepared to exhibit its position and appearance. However, as I have been disappointed in this respect, and our continued observations having placed the fact of the existence of the ring beyond question, I will now ask permission to communicate some extracts from our note-book. [The engraving has since been made.]

The first diagram of the new interior ring of *Saturn* was made by G. P. Bond, on the night of the 11th of November, 1850. The memorandum in the note-book runs thus:—

"November 11th, $22^h\ 50^m$ sidereal time, ($=7^h\ 30^m$ mean solar time,) very good definition. We notice to-night, with full certainty, the filling up of light inside the inner edge of the inner ring of *Saturn;* also, what is very singular, where the ring crosses the ball from *c* to *d* (referring to a diagram), or *below* the edge, there is a dark band, no doubt the shadow of the ring. But there is *also a dark line* from *a* to *b*, or above the ring, very plainly to be seen, as there can be no question of the line where the ring crosses the ball.

"The light which fills the corners of the inner ring at *x* and *y* is suddenly terminated on the side towards the ball. The light does not arise, I think, from any optical cause, for I cannot see why the same appearance should not be visible on the outside of the ring, or, indeed, of any object which we look at. Am very confident of having seen to-night a second division of the ring, near the inner edge of the inner ring."

"November 15th, 7^h 30^m. Examined the new ring of *Saturn* with different powers, best definition with 400. New ring sharply defined; edge next the ball. W. C. Bond thinks he sees the new ring clear of connection with the old, but the side next the old ring is not so definite as next the planet, so that it is not certain whether the new is connected with the old ring or not. Where the dusky ring crosses *Saturn*, it appears a little wider at the outside of the ball than in the middle. Where the new ring crosses *Saturn*, it appears not so dark as the shadow of the ring below on the body of the planet."

"8 P. M. The best definition of *Saturn's* ring we have ever had. G. P. Bond examined with powers 140 and 400. Cannot be sure that the new ring is divided from the old one, but there can be no doubt that it exists; its inner edge is sharply defined. I did once or twice fancy, with the higher powers, that there was a division between the old and new rings. All the southern region of *Saturn* is dusky and striped with belts.

Outer diameter of outer ring, ...	$=43''.9$
Inner diameter of inner ring, ...	$=29\ .3$
Breadth of outer ring, ...	$=\ 2\ .3$
Inner diameter of dusky ring, ...	$=26\ .3$
Distance of its inner edge from old ring, .	$=\ 1\ .5$

"According to Encke's measures, *Astr. Nach.*, No. 338, the inner diameter of the inner ring should be, at the above date, about $29''.8$; whereas, by the above measures, we make the inner diameter of the new ring to be only $26''.3$."

Our observations, continued to the 7th of January, fully confirmed the deductions which we had drawn from those of the 11th and 15th of November.

The same appearances were noticed by the Rev. W. R. Dawes, at his Observatory, near Maidstone, in England, on the 25th and 29th of November, and subsequently by Mr. Lassell, of Starfield, near Liverpool. An account of their observations is given in the Royal Astronomical Society's *Notices* for January 10th, 1851.

2. *On the Total Eclipse of the Sun, of July* 28, 1851; by R. T. Paine, Esq.—Although there will be many inducements for travellers from the United States to visit Europe this summer, it is believed there is no one stronger than the total eclipse of the Sun which will take place on Monday, the 28th of July, and which being visible over a great extent of the surface of the Earth, will be one of the most important that will happen for many years.

On this occasion a total or partial obscuration of the Sun may be seen throughout the greater part of North America, (Mexico and the southern extremity of Florida being excepted,) throughout Europe, in the western, northern, and northeastern parts of Asia, in the northern and northwestern parts of Africa, in Greenland, &c., whilst the line of the central and total eclipse will pass over 191 degrees of longitude, or from the vicinity of Sitka, the capital of the Russian settlements on our northwest coast, to the southeastern extremity of the Caspian sea.

But in no part of the United States will the eclipse be *total;* the greatest obscuration within our territory taking place at Cape Flattery,

in Oregon, at the entrance of the Straits of Fuca, where the Sun at $4^h\ 56^m$, A.M., or twenty-four minutes after it rises, will be about five-sixths (10° 3′) obscured on the north side. At San Francisco the greatest obscuration will take place before the Sun rises, but as the end of the eclipse may be seen, it is hoped it will be carefully observed not only there, but at every place in California and Oregon, where are suitable instruments, as a long time will elapse before another as favorable an opportunity offers, for the determination of the longitude.

Indeed, a *total* eclipse of the Sun at any particular place so seldom occurs, that but a small part of those inhabitants of the earth who remain stationary, ever have an opportunity of beholding this, the most sublime of all phenomena. In April, 1715, the Sun was entirely hidden by the Moon at London, and again in May, 1724, at Paris, but in the course of the long interval between those years and 1901, and perhaps much longer, the shadow of the Moon has not again passed, and will not, over either of those cities. The only total eclipse that has happened in Boston, since its settlement in 1630, as is believed, was that which took place under such very favorable circumstances, on June 16th, 1806, and by the list of eclipses from 1824 to 1901, originally published in the Columbian Sentinel, and afterwards in an abridged form in the American Almanac for 1831, it appears that there will not be any other, certainly within the present century; moreover, it is very probable, that there are many places in this country, at which there has not been, since their settlement by Europeans, even one.

It also appears, by the list above referred to, that in the course of the seventy-five years between 1826 and 1901, the shadow of the Moon passes but three times over any part of our widely extended Atlantic coast, viz. on November 30th, 1834, over a small part of Georgia and South Carolina; on August 7th, 1869, of North Carolina and Virginia, and on May 28th, 1900, over part of Virginia. Annular eclipses, it is true, occur more frequently, as those of April, 1791, and February, 1831, were, and those of May 26th, 1854, and September 29th, 1875, will be, visible in Massachusetts, or four in about a century and a quarter; but these eclipses, although beautiful, have little of the sublimity that attends a total obscuration.

Rare therefore, as is, in general, the occurrence of a central eclipse at any particular place, it occasionally happens, that some places are, in this respect, especially favored. Thus, the eclipse of July 8th, 1842 was, and that of the present year will be, central in Poland in lat. 50° 36′·7 N. long. 27° 5′·5 East, so that the inhabitants of that spot will have an opportunity of beholding two total eclipses of the Sun in the course of nine years. In this country the central path of February 12th, 1831, was crossed in Alabama by that of November 30th, 1834, and in Virginia by that of September 18th, 1838, and in 1853 the two eclipses of June 6th and November 30th, will both be central in the Pacific Ocean in long. about 125° West, lat. 2° South; these are, however, but exceptions to the general rule, and the places thus favored are nearly points on the surface of the Earth.

The width of the shadow of the Moon on the 28th of July next, will vary as usual whilst passing over the Earth, but in Greenland, Norway,

Sweden and Prussia it will be about 140 geographical miles. If, therefore, the central path given below, be carefully marked on a good map, and a line be drawn parallel thereto to the north and another to the south, at the distance of seventy miles or a little less therefrom, the places at which the eclipse will be total will be easily seen, there being of course some doubt as to those situated like Elsineur, just within the edge of the shadow, as a small error in the Moon's tabular latitude is not uncommon. Within the lines thus drawn are included in America several of the Russian settlements southeast of Sitka, part of British Oregon, two of the forts of the Hudson's Bay Company on the Great Slave Lake, the winter harbor of Capt. Ross in 1830, and of Capt. Parry in 1822, the Northern part of the Island of Disco, in Baffin's Bay and several of the Danish villages on the Western coast of Greenland; and in Europe the Northern part of Iceland, the astronomical observatories at Christiana, Koeningsburg, Warsaw, and Nicolaef, also the cities of Bergen, Gottenburg, Carlscrona, Calmar, Frederickshall, Jorkoping, Dantzic, Elbing, Pillau, Jitomir and Cherson; and in Asia, Tifflis and Bakou, between the Black and Caspian, besides many others of less note; but Sitka, and Stockholm, Copenhagen and Odessa are not included within these limits, the two former being situated a little too far to the north, and the two latter to the south.

The most favorable of all situations for observing the eclipse will be where central, on the western coast of Greenland, in the southern part of Norway, Sweden, and of the Island of Oland, and in Prussia, on the Baltic, between Dantzic and Koeningsburg; as the Moon being there quite high the duration of total darkness will be greater than where nearer the horizon. Thus where central, in the vicinity of Port Stewart, the Sun being low in the east, and of Tefflis, in the west, the duration of the total obscuration will be 2m. 26sec. and 2m. 31sec., at Fort Providence 2m. 49sec., in Greenland 3m. 49sec., near Bergen 3m. 38sec., near Pillau 3m. 20sec., and where central, in the vicinity of Nicolaef 2m. 55sec.

Although, as is above remarked, the diameter of the perfect shadow on the Earth, is only about 140 geographical miles, the extent of the partial shadow is comparatively very great. Indeed, if we reduce the time of the end of the eclipse at Sitka, and of the beginning at Warsaw, to a common meridian, as that of Greenwich, it will be seen that the latter precedes the former by one minute, so that although these places differ 156 degrees in longitude and their distance from each other is more than 5400 geographical, or 6200 English miles, the eclipse will begin at Warsaw on the right side of the Sun, 61 seconds before it will end at Sitka, on the left; the Sun, throughout the intervening space, being more or less obscured.

The elements of the Sun and Moon, for the following computations were deduced from the English Nautical Almanac, but their diameters and the parallax of the latter, were increased by the quantities recently recommended by Prof. Airy as the result of twelve years observations (1836 to 1847) at the Royal Observatory at Greenwich. The ellipticity of the earth being considered to be $\frac{1}{300}$th.

Path of the Central Eclipse, or of the centre of the shadow of the Moon over the Earth, on Monday, July 28th, 1851.

MEAN TIME AT GREENWICH.

Eclipse Central at	In Latitude.	In Longitude.	Eclipse Central at	In Latitude.	In Longitude.
h. m. sec.	° ′	° ′	h. m. sec.	° ′	° ′
1 25 46½	53 42·7 N.	137 47·6 W.	2 53 0	62 58·9 N.	0 0·6 E.
25 48	54 12·7	136 31·2	54 0	44·4	0 50·8
26 0	55 19·2	133 40·8	55 0	23·6	1 40·5
26 30	56 38·8	130 13·9	56 0	5·6	2 29·8
27 0	57 32·7	127 51·3	57 0	47·3	3 18·6
28 0	58 53·4	124 12·0	58 0	28·8	4 7·0
30 0	60 50·3	118 37·2	59 0	10·1	4 55·1
32 30	62 39·3	112 56·9	3 0 0	60 51·1	5 42·8
35 0	64 6·3	107 59·7	1 0	31·9	6 30·3
37 30	65 19·0	103 19·2	2 0	12·4	7 17·5
40 0	66 21·1	98 52·4	3 0	59 52·7	8 4·4
42 30	67 14·7	94 32·7	4 0	32·8	8 51·1
45 0	68 0·9	90 17·4	5 0	12·6	9 37·7
47 30	40·6	86 4·5	6 0	58 52·1	10 24·2
50 0	69 14·5	81 53·0	7 0	31·4	11 10·5
52 30	42·9	77 42·8	8 0	10·4	11 56·8
55 0	70 6·2	73 33·8	9 0	57 49·1	12 43·0
57 30	24·6	69 26·2	10 0	27·5	13 29·3
2 0 0	38·3	65 20·5	11 0	5·6	14 15·7
2 30	47·5	61 17·3	12 0	56 43·4	15 2·2
5 0	52·5	57 17·4	13 0	20·8	15 48·8
* 7 0	53·6	54 8·4	14 0	55 57·9	16 35·6
7 30	53·4	53 21·6	15 0	34·7	17 22·8
10 0	50·5	49 30·7	16 0	11·0	18 10·4
12 30	43·9	45 45·2	17 0	54 47·0	18 58·3
15 0	33·9	42 5·7	18 0	22·6	19 46·6
17 30	20·6	38 32·8	19 0	53 57·8	20 35·5
20 0	70 4·3	35 6·9	20 0	32·5	21 25·0
**21 2½	69 56·7	33 42·9	21 0	6·6	22 15·3
22 30	45·1	31 48·0	22 0	52 40·1	23 6·4
25 0	23·3	28 36·3	23 0	13·2	23 58·5
27 30	68 59·0	25 31·7	24 0	51 45·7	24 51·7
30 0	32·3	22 34·2	25 0	17·6	25 46·3
31 0	21·0	21 25·1	26 0	50 48·7	26 42·2
32 0	9·4	20 17·2	27 0	18·9	27 39·7
33 0	67 57·4	19 10·3	28 0	49 48·2	28 39·2
34 0	45·1	18 4·4	29 0	16·5	29 40·9
35 0	32·5	16 59·5	30 0	48 43·6	30 45·2
36 0	19·6	15 55·6	31 0	9·4	31 52·7
37 0	6·4	14 52·8	32 0	47 33·6	33 3·9
38 0	66 52·9	13 50·9	33 0	46 55·9	34 19·5
39 0	39·1	12 49·9	34 0	15·9	35 40·8
40 0	25·1	11 49·8	35 0	45 33·2	37 9·6
41 0	10·8	10 50·6	36 0	44 46·5	38 48·1
42 0	65 56·2	9 52·3	36 30	21·2	39 42·0
43 0	41·3	8 54·8	37 0	43 54·4	40 40·8
44 0	26·2	7 58·1	37 30	25·5	41 45·2
45 0	10·8	7 2·2	38 0	42 53·7	42 56·6
46 0	64 55·1	6 7·0	38 30	17·9	44 19·0
47 0	39·2	5 12·5	39 0	41 35·7	45 58·9
48 0	23·1	4 18·8	39 30	40 40·0	48 16·1
49 0	6·7	3 25·7	39 40	13·9	49 22·6
50 0	63 50·1	2 33·2	39 50	39 33·7	51 7·8
51 0	33·3	1 41·4	39 53	38 59·1	52 41·9
52 0	16·2	0 50·1			

* Greatest north latitude of the central path. ** On the meridian of the place.
Duration of the central eclipse on the earth 2h. 14m. 6½sec.

The beginning and end, &c. of the eclipse at the following places are expressed in mean and civil time of each particular place. The angles of the points on the Sun's disc, at which the obscuration will begin and end are counted from the vertex or highest point of the Sun towards the right hand, as seen through a telescope that does *not* invert; for an astronomical telescope, 180 degrees should be added thereto.

The Sun will rise at Sitka and Port Stewart at 3h. 56m. and 4h. 3m. and will set at Tifflis at 7h. 20m. The obscuration at the Observatory at Cambridge will be on the northern, and at Sitka on the southern limb of the Sun.

	Sitka.	Cambridge Observatory.
Latitude,	57° 2′ 54″	42° 22′ 48″
Longitude West,	135 17 12	71 8 2
	h. m. sec.	h. m. sec.
Beginning of the eclipse,	— — — A.M.	7 48 10 A.M.
Greatest obscuration,	4 27 36	8 37 51
End of the eclipse,	5 19 38	9 31 18
Duration of the eclipse,	— — —	1 43 8
Digits eclipsed,	11° 51′ —	3° 47′
Angle of beginning,	— — —	350°·9
" end,	231°·4 —	262°·1

	Port Stewart.	F. Providence.	Niakernak.
Latitude,	55° 38′ 18″	62° 17′ 19″	70° 47′ 0″
Longitude West,	131 47	114 9 28	53 23 36
	h. m. sec.	h. m. sec.	h. m. sec.
Eclipse begins,	— — — A.M.	5 1 2 A.M.	9 29 56 A.M.
Total eclipse begins,	4 37 26	5 53 54	10 32 1
Least distance of centre,	4 38 35	55 22	33 50
Total eclipse ends,	4 39 45	56 42	35 39
Eclipse ends,	5 31 11	6 52 18	11 38 45
Duration of total eclipse,	2 19	2 48	3 38
Duration of whole do.	— — —	1 52 16	2 8 49
Angle of beg. of eclipse,	— — —	58° ·7	67°·5
do. of end of eclipse,	232°·1	235°·9	257°·5
At the least distance of centres,	Moon N. 11″·96 diff. S. D. 45″·53	Moon south 0″·43 diff. S. D. 49″·05	Moon north 4″·43 diff. S. D. 55″·06

	Bergen.	Christiana.	Gottenburg.
Latitude,	60° 24′ 0″	59° 54′ 42″	57° 42′ 4″
Longitude East,	5 18 3	10 43 31	11 56 39
	h. m. sec.	h. m. sec.	h. m. sec.
Eclipse begins,	2 15 45 P.M.	2 42 35 P.M.	2 51 48 P.M.
Total eclipse begins,	3 19 59	3 45 54	3 54 54
Least distance of centres,	21 42	47 15	56 36
Total eclipse ends,	23 24	48 37	58 18
Eclipse ends,	4 24 6	4 48 18	4 57 26
Duration total eclipse,	3 25	2 43	3 24
" whole do.	2 8 21	2 5 43	2 5 38
Angle of beg'g. of eclipse,	97°·5	102°·3	103°·8
" of end,	287°·3	287°·4	291°·1
At the least distance of centres,	Moon N'rth 18″·88 diff. S. D. 55″·24	South 34″·70 54″·58	North 13″·67 54″·50

	Dantzic.	Pillau.	Koningsburg.
Latitude North,	54° 24′ 15″	54° 33′ 39″	54° 42′ 50″
Longitude East,	18 40 15	19 52 30	20 30 6
	h. m. sec.	h. m. sec.	h. m. sec.
Eclipse begins,	3 29 7 P.M.	3 34 28 P.M.	3 37 7 P.M.
Total eclipse begins,	4 30 37	4 35 34	4 38 7
Least distance of centres,	32 14	37 13	39 39
Total eclipse ends,	33 51	38 52	41 10
Eclipse ends,	5 31 10	5 35 49	5 38 4
Duration total eclipse,	3 14	3 18	3 3
" whole "	2 2 3	2 1 21	2 0 57
Angle of beginning,	110°·0	111°·0	111°·4
" of end,	294°·6	293°·6	293°·1
At the least distance of centres,	Moon N'rth 14″·58 diff. S. D. 53″·43	South 6″·80 diff. S. D. 53″·28	South 20″·02 diff. S. D. 53″·13

	Warsaw.	Nicolaef.	Tiflis.
Latitude,	52° 13′ 5″	46° 58′ 21″	41° 41′ 4″
Longitude East,	21 2 9	31 58 48	44 50 40
	h. m. sec.	h. m. sec.	h. m. sec.
Eclipse begins,	3 43 54 P.M.	4 42 13 P.M.	5 44 31 P.M.
Total eclipse begins,	4 45 25	5 39 44	6 37 21
Least distance of centres,	46 20	40 50	38 35
Total eclipse ends,	47 16	41 56	39 48
Eclipse ends,	5 44 27	6 35 19	— — —
Duration total eclipse,	1 51	2 12	2 27
" whole do.,	2 0 33	1 53 6	— — —
Angle of beginning,	112°·5	120°·5	126°·2
" of end,	297°·2	300°·4	— — —
At least distance of centres,	Moon N'rth 43″·58 diff. S. D. 52″·93	North 32″·97 diff. S. D. 50″·39	North 11″·90 diff. S. D. 47″·02

At Carlscrona, lat. 56° 9′ 31″, lon. 15° 35′ 13″ E., the apparent North latitude of the Moon at 4h. 15m. 35sec. will be 8″·41, and the eclipse will be total from 4h. 13m. 51sec. to 4h. 17m. 16sec.

At Elsineur, lat. 56° 2′ 20″, lon. 12° 37′ 30″ E., the least distance of the centres (53″·84) will take place at 4h. 2m. 34sec., and as the difference of the semi-diameters is 54″·45, the eclipse by computation will be total there.

At Copenhagen, in lat. 55° 40′ 53″, lon. 12° 34′ 57″ E., the least distance (65″·28) will take place at 4h. 3m. 1sec., and the magnitude of the obscuration will be 11° 56′ on the north limb of the Sun.—*Boston Daily Advertiser.*

Boston, March 26th, 1851.

V. Miscellaneous Intelligence.

1. *Electro-magnetic Locomotive*, (From the National Intelligencer of May 3, 1851.)—We lay before our readers a statement from Professor Page respecting the *Electro-magnetic Locomotive;* and when we regard the fact that the highest power ever attained before his experiments was less than half a horse power, and that costing probably one hundred times as much as it does under this new mode of its application, we cannot be indifferent to so great a result, and the high promises with which it seems to be fraught:

Messrs. Editors:—The electro-magnetic locomotive made a very favorable trip on Tuesday last, more especially when it is taken into the account that we were constrained to make this trial with only one-

half (or even a little less,) of the power the engines and battery are capable of yielding. Each engine, calculated upon the basis of my stationary engine, ought to give at the lowest estimate 12 horse power, which would make the locomotive 24 horse power. The actual power I have not been able to ascertain; but the following data may serve to give some idea of its power. The locomotive, with the battery fully charged, weighs ten and a half tons. With the seven passengers taken on the trip to and from Bladensburg the weight was eleven tons. Under the most favorable arrangements *eight pounds* are required to start a ton on a perfectly level rail, and seven pounds will barely keep a ton in motion. Ordinarily, upon railroads the allowance is ten pounds to a ton, but this applies only to cars unincumbered by machinery. The friction of locomotive machinery renders its draught far greater, and can only be accurately ascertained by experiment in each case. The magnetic locomotive, the first of its kind ever made, is imperfect, and, from the newness and stiffness of all the work, it runs exceedingly hard. We will take 200 pounds, which is below its actual power required to keep it in motion on a level portion of the road. A horse power upon the usual estimate is 150 pounds $2\frac{1}{2}$ miles an hour, or 375 pounds 1 mile an hour. The speed of the magnetic locomotive is, we will say, 15 miles an hour on a level road, (it has in fact made more,) and its traction 200 pounds. We have then 375 pounds 1 mile an hour for one horse, and 200 pounds 15 miles an hour for the locomotive, which gives *eight* horse power. But the engine has more than this. It has greater power at a slow speed, and must have, by all reasonable estimates, twelve horse power; which, as I said before, is about one-half its proper capacity. One of the most serious defects arises from a want of insulation in the helices. After the engine was placed on the road it was found neccessary to throw out of action five of the helices, and these at the most important point in the stroke. This difficulty could not be remedied without taking both engines entirely out—an undertaking for which I had neither time nor means, as the track with which we are now accommodated is soon to be filled up for the purposes of the Railroad company. Another serious difficulty encountered was the breaking of the porous cells in the battery, causing a mixture of the two acids, and the interception of a large portion of the power. I had great difficulty in procuring suitable porous cells, and the manufacture of such as I needed was, after a great expense, given up by two of the best pottery establishments in the country as a thing impracticable. It was, however, accomplished through the ingenuity of Mr. Ari Davis, my engineer, but they were made of a weak clay, and have now, from frequent use, become so much impaired as to break from the slightest causes. Before we started two of them broke, and the defect was only partially repaired. Not far from Bladensburg two more gave way, and detracted at once greatly from our working power. On our return, about two miles from Bladensburg, three more gave way, and we were reduced to at least one-half of our power. The running time from Washington to Bladensburg was thirty-nine minutes. We were stopped on the way five times, or we should have probably made the run in less than thirty minutes. Going and coming there were seven stops and three delays—that is, the engine

was backed three times, but without entirely losing headway. It is a very important and interesting feature of this engine, which I demonstrated some years since, that the reversing power is greater than the propelling power; it is nearly twice as great. When the engine is reversed, the magnetic electric induction is in favor of the battery current, and augments its effects. The defect of the cells is easily remedied. The trouble growing out of the oscillating motion of the car can all be obviated by using rotary instead of reciprocating engines. The greatest speed attained on our last trip was about nineteen miles an hour, and about seven more than in any former experiment.

Washington, May 1, 1851. CHARLES G. PAGE.

2. *Meeting of the American Association for the Advancement of Science at Cincinnati.*—The Cincinnati meeting of the Association commenced on Monday, May 5th, and continued through the week. The attendance was large, and the papers presented numerous and important, as will be seen from the following catalogue. The department which had the most attention was that of Geology, while at the preceding meeting at New Haven there were very few papers on this subject. The papers read are as follows:—

ASTRONOMY, MATHEMATICS, PHYSICS, &c.

On the limit of perceptibility of a direct and reflected sound. By Prof. HENRY, of the Smithsonian Institution.

On an Apparatus for determining Altitudes by means of the Boiling Point. By Prof. J. HENRY.

On the Constitution of Saturn's Ring. By Prof. PEIRCE, of Harvard.

Report of the Committee upon Prof. MITCHEL's System of Astronomical Observations. By Prof. PEIRCE, Chairman of the Committee.

On a Method of determining the Velocity of Sound by Coincidences. By Prof. A. D. BACHE, Superintendent of the U. S. Coast Survey.

Notes on the Zenith Telescope in determining latitudes in the Coast Survey, by Talcott's Method, and on the reduction of the Observations. By Prof. A. D. BACHE.

Current Chart of New York Bay, from Observations in the Coast Survey. By Prof. A. D. BACHE.

Comparison of Curves showing the hourly changes of Magnetic Declination at Philadelphia, Toronto, and Hobartown. By Prof. A. D. BACHE.

On a Modification of Apparatus for the Registration of Time, for Astronomical Purposes by means of Electricity. By W. WURDEMANN, of Washington City.

On the Motion of the Sun about the Centre of Gravity of the Solar System. By Prof. GEO. W. COAKLEY, of St. James.

On a new method of geometrically constructing the Integration by Quadratures. By Rev. TH. HILL.

On the Longitude of the Cincinnati Observatory by Telegraphic Operations, in connection with the U. S. Coast Survey. By Prof. O. M. MITCHEL, Director of the Cincinnati Observatory.

On a new Theory of Statements by Proportions. By Prof. THOMAS RAINEY, of Cincinnati.

On a method of distinguishing between Bi-axial and Uni-axial Crystals when in thin plates, and the results of the examination of several supposed Uni-axial Micas. By WILLIAM P. BLAKE, of New York.

On the Orbital courses of Storms, as opposed to the received hypotheses of general winds, founded on the alleged influence of equatorial temperature. By W. C. REDFIELD, Esq., of New York.

On the Mean Temperature of Cincinnati, and the Methods of calculating Mean Temperatures. By Dr. JOSEPH RAY, of Cincinnati.

On the Effects of the Areas of Oceanic Temperatures on Meteorological Phenomena. By Capt. C. WILKES.

On a new Form of Railroad Curves. By Rev. TH. HILL.

On a curious fact in relation to a Turbine Wheel. By Mr. CHASE, of Mass.

Chemistry and Mineralogy.

On the Detection of Organic Miasm in the Air. By George C. Schaeffer, Prof. of Chemistry and Natural Philosophy, Centre College, Danville, Ky.

On the Cause of Saltpetre Explosions. By George C. Schaeffer, Danville, Ky.

On the Chemical Effects produced by feeble electrical currents. By Daniel Vaughan.

On the existence of Phosphorus in certain Des Moines Iron Stones. By Doct. D. D. Owen, U. S. Geologist of the Chippewa Land District.

On the Association of certain Minerals in Northern New York. By Franklin B. Hough, M.D.

Geology.

Results of an Exploration of the Coral Reefs of Florida, in connection with the U. S. Coast Survey. By Prof. L. Agassiz, of Harvard.

On the Post-Permian date of the Red Sandstone Rocks of New Jersey, and the Connecticut Valley, as shown by fossil remains. By W. C. Redfield, of New York.

On the Fossil Rain-marks in the Red Sandstone Rocks of New Jersey and Connecticut, and their authentic character. By W. C. Redfield, of New York.

Parallelism of the Palæozoic Rocks of New York with those of the Western States, and of all these with the Palæozoic strata of Europe. By Prof. James Hall,

On the Silurian Rocks of the Lake Superior Land District. By Prof. James Hall, Palæontologist of the Survey.

On the Number and Distribution of Fossil Specimens in the Palæozoic Rocks of Iowa, Wisconsin, and Minnesota. By Drs. D. D. Owen, and B. Schumard, of New Harmony, Ind.

On the Palæontology of the Lowest Sandstones of Wisconsin, Iowa, and Minnesota. By D. D. Owen, M.D.

Abstract of an Introduction to the final Report on the Geological Surveys made in Wisconsin, Iowa, and Minnesota, in the years 1847–8–9 and 50, containg a Synopsis of the Geological features of the country. By D. D. Owen.

On the Azoic System of Lake Superior. By Messrs. Foster and Whitney, U. S. Geologists of the Lake Superior Land District.

On the age of the Sandstone of Lake Superior, with a description of the phenomena of the associated igneous rocks. By Messrs. Foster and Whitney.

On the different Systems of Elevation which have given configuration to North America. By J. W. Foster, U. S. Geologist for the Land District of Lake Superior.

On the Superficial Deposits of the North-West. By Charles Whittlesey, of the U. S. Geological Survey of Lake Superior.

On the Equivalency of the Rocks of North Eastern Ohio and the Portage, Chemung and Hamilton Rocks of New York. By Charles Whittlesey, Esq.

On the Goniatite Limestone of the Black Slate of Rockford, Jackson County, Indiana. By D. Christy, of Oxford, Ohio.

On Quartz Pebbles in the Sandstone Conglomerate, and Reasons for rejecting the Theory of Water Detrition. By Prof. J. Brainerd, of Cleveland.

Notes on the Survey of the Boundary betweeen the United States and Mexico. By Maj. W. W. Emory.

On the law of deposit by the flood tide. By Lieut. Charles H. Davis, U.S.N., Superintendent of the American Nautical Almanac.

Report of the Committee appointed to memorialize the Legislature of Pennsylvania in reference to the publication of the final geological report of that State. By Solomon W. Roberts, Civil Engineer.

Zoology and Botany.

On the limits of the class of Polypi and the rank and succession of their chief natural divisions. By Prof. L. Agassiz, of Harvard.

On some Points of the Structure and Reproduction of Physalia. By Prof. L. Agassiz.

On the special Homologies of the true Star Fishes and Crinoids. By Prof. L. Agassiz.

On the special Homologies of Acephala. By Prof. L. Agassiz.

Report on the Vertebrate fossils exhibited before the Association. By Prof. L. Agassiz.

On the structure and reproduction of Porites. By Prof. L. AGASSIZ.

On the Holothuriæ of the Atlantic Coast of the United States. By L. F. POURTALES, of Washington.

On the Gephyrea of the Atlantic Coast of the United States. By L. F. POURTALES.

On a specimen of the Fossil Ox, found in Trumbull Co., Ohio. By Prof. SAMUEL ST. JOHN, of Cleveland.

Remarks on the sexes and habits of some of the acephalous Bivalve Mollusca. By Dr. J. P. KIRTLAND.

On the Distribution of Crinoidea in the Western States. By Dr. L. P. YANDELL, of Louisville.

On the Geographical Distribution of some species of Terrestrial and Fluviatile Shells. By Dr. J. S. NEWBERRY.

Report on the Invertebrate fossils exhibited before the Association. By Prof. J. HALL.

On certain Human and other bones from a cave near Elyria, Ohio. By CHAS. WHITTLESEY, Jr., of Cleveland.

On the Flora of Texas. By Dr. GEO. ENGELMANN, of St. Louis.

On the History and Nomenclature of some cultivated Vegetables. By Dr. T. W. HARRIS, of Harvard College.

3. *Gold in Arkansas*, (from the N. O. Bee.)—Some weeks ago we mentioned the fact that Mr. Snell, an accomplished mineralogist of our city, had discovered, in the course of scientific exploration in certain portions of Arkansas, unmistakeable indications of an auriferous deposit. Mr. S. had in one instance picked out of the crevice of a rock a piece weighing about an ounce, in which gold was abundantly intermixed with the quartz, in the usual mechanical combination in which the two are found. Although this was but an isolated discovery, Mr. Snell predicted, with a confidence based upon the geological peculiarity of the country, that gold existed there probably in sufficient quantities to remunerate labor and enterprise. His prediction has been speedily verified.

Yesterday we had the pleasure of examining three very handsome specimens of Arkansas gold, as genuine as any that ever glittered amidst the sands of California. They were found in the bed of White river, some miles above Batesville, and in a range of rocky country, precisely similar in feature to the region where Mr. Snell obtained his specimen. The largest lump was a mass of quartz of a dirty white color, profusely penetrated by the precious metal, and in some places so completely mingled with it, that the gold seemed like an integral part of the rock. The other samples were smaller, and presented nearly a similar appearance. We presume that in the three pieces there could hardly have been less than five or six ounces of pure gold. These products of the mineral wealth of Arkansas were sent to Mr. Snell to be assayed.

4. *Rise and Fall of Lake Erie*, (from the Buffalo Advertiser of April 16.)—Various papers have recently alluded to the rise and fall of Lake Erie, maintaining that it is periodical every few years. The following memorandum, made by one of our intelligent citizens, who has carefully watched the rise and fall since 1839, settles the matter most conclusively.

The Toledo *Blade* represents Lake Erie as falling, and that there is a periodical rise and fall of its surface, once in twelve or fourteen years.

Some of your readers may be pleased to get *facts* from authentic records.

The highest state of the lake in calm weather ever recorded, was in June, 1838, when it stood 5 feet 4 inches above the zero at Buffalo:

	ft.	in.		ft.	in.
1839, May 11, it stood,	3	5	1846, May 16,	2	
1840, May 14,	3	9	1847, May 16,	2	6
1841, May 18,	3	1	1848, May 1,	2	2
1842, May 5,	3	7	1849, May 19,	3	1
1843, May 15, (supposed,)	2	8	1850, May 12,	2	8
1844, May 12,	2	11	1851, April 8,	2	11
1845, May 15,	3				

The very highest on record was by the tempest in the night of the 18–19 October, '44, at which time it rose to *thirteen feet eight inches* above the zero at Buffalo.

The very lowest on record, caused by a strong gale from northeast, was in the afternoon of the 18th of April, 1848, when it fell to 22 inches below zero.

The idea of a periodical rise and fall, once in a few years, is repudiated by exact observers.

The general observation is, that the surface reaches its maximum for the year, about the first of July, then falls a little to about the first of October, then rises slowly to about the first of December, then falls rapidly to about the tenth of February, then rises (in March very rapidly) and continues to rise until July.

OBITUARY.

Dr. S. G. Morton.—With sadness we record the death of an eminent man from the ranks of American science, Dr. Samuel George Morton of Philadelphia. He died on the 15th of May last, in his 53d year. The following paragraphs from obituary notices published upon his decease, but imperfectly express our own high estimate of his learning and his many personal excellencies.

Dr. Morton was a native of Philadelphia, born in connection, we believe, with the Society of Friends, which has given to it so many citizens distinguished in the walks of science. Adopting the medical profession, which he studied under the auspices of the late Dr. Isaac Parrish, he received the honors of the doctorate from the University of Pennsylvania, but afterwards proceeded to Edinburg, where he graduated again with distinction, highly esteemed for his literary abilities, as well as his professional proficiency. Young, ardent, with the enthusiasm of a poetical temperament—for poetry was his first ambition—but a manly sense and purpose that enabled him to postpone the imaginative to the solid and useful, he made the tour of Europe, shook hands with warm friends and relatives in Ireland, the land of his ancestors, where strong inducements were offered to retain him, and returned to his native country, and to his native city, here to commence a career which, even at that early moment, he had marked out, and to build up for himself a name not likely soon to be forgotten. It is scarce necessary for us to refer to the success of his professional or merely medical career. That was always great. For years, no physician in Phil-

adelphia could boast a larger, few an equal practice. His claims to distinction, in this capacity, were proved by his well known work on Consumption and other valuable publications, as well as by his lectures at the Philadelphia Hospital, Pennsylvania College, and other medical institutions with which he was at different times connected.

One would suppose that with the burthen of his heavy practice, and all the addition of these laborious collaterals pressing upon him, he could find but little leisure for other pursuits, and indulge but small hope of acquiring fame in a different path. His history is an example of what men *can* do, even under adverse circumstances, who are patient, who are resolute, who are industrious, who are wise, who are true to themselves and sufficient to themselves. Ever calm, but ever active, always prepared for the exigencies of his business duties, and ever ready to devote to profitable use the scanty intervals of leisure which those duties allowed him, he found time for continual participation in scientific affairs, and in the proceedings of the Academy of Natural Sciences, of which he was for thirty years a member—and for many years its Vice President and President; and, what is more, with the additional incumbrance of this general scientific participation, he found time also to produce those great works, the *Crania Americana* and *Crania Ægyptiaca*, which immediately placed him in the front rank of archæologists and ethnographers throughout the world. The appearance of the first named of these volumes established an era; it opened a new department of research; it created a new science—one that has done more for the true exposition of human history, the interpretation of the mysteries of race differences and race affinities—far more than any thing ever previously effected by the pen of the annalist or the wand of science. Few scientific works ever produced a stronger or more durable impression on the philosophic mind, or have had a more powerful effect in directing the course of future investigations.

But we have no space to write the history or attempt the eulogium of Dr. Morton. That task will fall to more competent hands; though it could be undertaken by none who knew him better or prized him more. It will be all the more justly executed where there is a less lively sensibility or less oppressive appreciation of his loss. Let us say of him, only, that he was a good, as well as great man; estimable in all his relations; respectable in all he thought and did; a man of pure heart and blameless life; a faithful physician; a kind friend; a loving husband and father; a gentle companion; an exemplary citizen.

It is only at the hour of his death, that many, who knew Dr. Morton well, will be conscious that a great man has been taken away, and a light quenched which has long shed a common lustre upon the country and the world.—*North American*, Philadelphia.

Few men more respected and beloved have been taken from us than Dr. Samuel George Morton, and few more respected and beloved remain. It is not only in the domestic and social relations, as husband, brother, friend and neighbor, that his place cannot be supplied: but his position in the profession, and as a man of science, it will be equally difficult to fill. His whole character was marked by singular proprie-

ties. As a man and a gentleman he was equally amiable and accomplished, simple and dignified. Few men of so extended reputation appeared so unconcious of it; few men accomplished so much with so little apparent effort; few combined more varied powers, or a greater variety of excellent traits, all founded on solid worth. Few men brought a happier countenance into a sick chamber, or inspired more confidence while there, or commanded more respect in consultation. Few understood better those nicer delicacies and discriminating proprieties which should govern a man in those peculiar trials which the profession sometimes presents.—*Evening Bulletin*, Philadelphia.

Seldom has our city been more deeply moved in its literary and professional ranks, by the ravages of death, than during the past week, in the comparatively sudden and unexpected decease of Dr. Samuel George Morton. After a short sickness of about four days, disease had done its perfect work. Little did we think, as we saw him in God's house on the Sunday previous to the fatal attack, that he was never to tread those courts again; that we were delivering to one immortal being at least, the last public ministrations of grace that would ever fall upon his ear. The manly form, the gentle mien, the thoughtful manner, the apparent vigor, gave hope and promise for future years of toil and usefulness. * * * *—*Episcopal Recorder*, Philadelphia.

Dr. Morton's collection of Crania, the basis of his principal work, is the largest in the world, and is the great feature in the museum of the Academy of Natural Sciences in which it is deposited. It was collected at his own private expense and by his individual exertions. His zeal in scientific research was not less to be admired than his cool judgment, clear discrimination, and deference for the opinion and feelings of others. "In France," said the late lamented Dr. Prichard, "where scientific men have long been devoted, under the patronage of the government, to researches on this subject; in England, possessed of her immense advantages of wealth and intercourse: in the academies of Italy and Germany; in all of these and with all their advantages, nothing has been done which equals the results of Dr. Morton's unaided labors, in a world which we call new."

The impetus which he gave to this branch of science has been felt even in Russia, where the Emperor has founded in St. Petersburg a national museum which can only hope to equal that of our lamented countryman. Wherever science has her votaries, the news of Dr. Morton's death will carry pain. * * *—*New York Tribune of May 20th.*

Dr. Morton was President of the Academy of Natural Sciences of Philadelphia at the time of his decease, and his loss falls with special severity upon the members of the Academy who have found in his life, as their resolutions say, "an example of earnest and successful zeal in the pursuit and promotion of learning, in the cultivation of wisdom and virtue, and in the practice of the highest liberality and benevolence." A marble tablet to his memory, appropriately inscribed, will be placed by the Academy in its hall.

OERSTED.—The name of HANS CHRISTIAN OERSTED, the discoverer of electro-magnetism, has been added to the long list of those whom continental science has recently been called upon to mourn. It has been truly said of him, that the position which he occupied in Denmark was very similar to that of Humboldt in Germany. He was the philosopher, the scientist, the scholar,—the kind friend of youth, the judicious counselor of age,—one whom monarch and citizen alike delighted to honor. Oersted was born 1777, August 14, in Rudkjöbing, a small town on the Danish island of Langeland. The poverty of his parents and the isolation of their little village were alike unfavorable to the attainment of a thorough education. But Oersted, like many of his predecessors in the same path, learned for himself the elements of knowledge, and especially arithmetic, from old schoolbooks which fell in his way, and taught his brother *Anders* who was a year younger, all that he had thus acquired for himself. And like the brothers Humboldt, the brothers Oersted seemed in after life almost to divide between themselves the realm of human knowledge. While in each case one brother followed the paths of actual science and adorned the university and the academy,—the other rose to equal eminence in the other division of human knowledge, and finally became minister of state.

Oersted came to Copenhagen in his 18th year, and devoted himself to his studies with intense zeal. His fellow student, Oehlenschläger, afterwards the celebrated poet, was at this time almost the only person who shared his friendship with his brother, and the intimate friendship thus begun continued undiminished and uninterrupted till dissolved by death.

In 1799, Oersted published his inaugural dissertation on the "Architecture of Natural Metaphysics," (*Architectonik der Naturmetaphysik.*) This treatise shows that, even at that period, his mind was deeply imbued with tastes and sentiments similar to those which characterize the last writings of his life.

At this time he proposed his new theory of the alkalies, a theory which was afterwards universally adopted. In 1800, he was appointed adjunct in the medical faculty of the University, and began to lecture on chemistry and the philosophy of nature.

This was the year in which Volta discovered the battery which bears his name; setting this discovery, as Möller has admirably said, like a milestone at the close of one century and the beginning of the next. All Oersted's energies were immediately enlisted for the new field of research thus opened, and he immediately detected the true law of the decomposition of salts. From this time forward he dedicated himself solely to the career of an investigator, and in the pursuit of his studies visited almost all parts of northern Europe.

His subsequent life is well known to the scientific world. In the year 1820 he discovered the magnetic influence of electricity, thus founding the science of Electro-magnetism and in fact first opening that new course of research into the mutual relations of the several energies of nature, which is still pursued with such brilliant success, yearly leading to more and more astonishing results. Without the discoveries of Oersted, where had been those of Ampère, Arago, Faraday, Seebeck and Melloni? In 1814 he established a Magnetic Observatory at Copenhagen, but has since that time chiefly devoted himself to those sciences which spring from the mutual relation of the material and spir-

itual worlds. His books on "The Spirit in Nature," "Natural Science and Spiritual Culture," "Natural Science in its relation to Poetry and Religion"—must be and continue classic works, whatever may be individual views of the correctness of their philosophy. The bishop of Seeland has very recently published a severe attack upon Oersted's views, occasioned by the publication of his "*Geist in der Natur*." But although Denmark has been one of the last continental nations to learn how little our knowledge of the truth is advanced or facilitated by contests between theologians and scientists; the reception of Bishop Mynster's book shows that the great fact—that the true interpretation of revelations through moral and through physical media must necessarily coincide—is now at last appreciated in Denmark also.

The fiftieth anniversary (jubilee) of Oersted's appointment to his professorship in the University of Copenhagen was recently celebrated with great pomp. All ranks vied in showing him honor. The king conferred on him the highest civil distinction,—the grand cross of the Dannebrog—the University sent new insignia of his Doctor's degree, with a gold ring bearing a carved head of Minerva, and the citizens presented him with a beautiful countryseat at Friedrichsburg, in the immediate environs of the capital. A late newspaper in narrating the facts, adds, "King and people agree in a strange estimate of the value and station of the scientific man, according to our insular notions. We do not see how they could have improved on this sort of testimonial if he had gained a battle!"

The following account of his burial is from the Athenæum, of April 5:—"It may perhaps be interesting to some of our readers to know how they bury a philosopher in Denmark. The illustrious Oersted has gone to his grave with a *cortège* such as waits on the funeral march of kings. Thirty thousand persons—one-fourth of the entire population of the capital—formed the procession which conducted him to his final place of repose. At the head of this crowd, the King was represented by his first aide-de-camp,—followed by the heir to the crown and other princes of the blood. Then came the Chambers of the Diet, the Ministers, the Council of State, the Clergy, the Professors of the University and of the other educational establishments of Copenhagen, the Academies of Science and Fine Arts and other learned corporations, the army staff, nearly all the members of the diplomatic body, the municipality, the youth of the schools, the trading corporations, and finally men of every rank and class—all contributing their several distinctions to swell the one act of homage to him who had done so much to popularize science in Denmark. The thing was not according to the rules:—the Herald was not fairly represented in a procession like this. But rules which were to be immutable are giving way on every hand:—and the Herald, who shows as so great a figure through the twilight of the middle ages, is a mere phantom in the light of modern days."

B. A. G.

Jacobi.—Carl Gustav Jacob Jacobi was born in Potsdam, 1804, Dec. 10. His father was a silversmith, of the Jewish faith. He was educated under the care of his uncle, F. A. Lehmann, and entered the Gymnasium at Potsdam in 1816, the Berlin University in 1820, dividing his studies between the three departments, Mathematics, Philosophy and Philology. His Dissertation on leaving the University in 1825, is

entitled, "Disquisitiones Analyticæ de Fractionibus Simplicibus," and is a treatise of great analytic value. Among the theses which he defended at this time, was the truth of the couplet of Novalis,

> "Der Begriff der Mathematik ist der Begriff der Wissenschaft überhaupt.
> Alle Wissenschaften müssen daher streben Mathematik zu werden."
>
> The idea of Mathematics is the idea of Science in general;
> All sciences must therefore strive to become Mathematics.

The wide scope of Jacobi's studies and the many-sidedness of his culture, give to his strong opinion a peculiar weight.

He went to Königsberg in 1825, and was appointed Professor in that University in 1827, a post which he retained until his death,—though on account of the severe climate of Königsberg he has resided in Berlin for several years, and lectured in that University in his character of academician. His chief investigations have been connected with the theory of elliptic functions, and are published in the Memoirs of the Berlin Academy and in Crelle's Journal. The first volume of a contemplated collection of his complete works appeared in 1846.

Prof. M. H. Jacobi, the electrician, the discoverer of the galvano-plastic art, now a resident of St. Petersburg, is a brother of the deceased.

An apt illustration of the high repute of Jacobi is furnished by an incident which occurred about a twelvemonth before his death. In consequence of the extreme liberality of the opinions which he entertained at the time, his salary was reduced by the Prussian government. But no sooner had this been done, than the *Austrian* government invited him to the University of Vienna, at a salary equal to the former one, and the Prussians were thus unwillingly compelled not only to restore all arrearages, but also to establish his salary at a higher rate than before.

His personal character was very peculiar. His enthusiasm was great, his prejudices strong, his sarcastic powers hardly exceeded by those of Lichtenberg himself. He took a warm interest in the recent political disturbances of Prussia, although his position was extremely undefined; being characterized at one time by the strongest loyalty, at another by the most fervent republicanism. In Jacobi, science has not only lost one of her brightest ornaments, but a powerful defender of her interests, —a champion who knew not how to yield. In the words of a colleague in a recent letter to the writer, "The loss is not only for science, but for all who honor her, for she has lost a defender, able and earnest, when her welfare was concerned, to set in motion all the powers above and beneath, to break and hew open a path for her." B. A. G.

VI. Bibliography.

1. *Astronomical Observations, made under the direction of* M. F. Maury, Lieut. U. S. Navy, during the year 1846, at the National Observatory, Washington. Vol. II, published by authority of the Secretary of the Navy. pp. lxvi, 442, with an appendix of 167 pp., 4to. Washington, 1851.—This volume commences with an account of several of the prominent instruments of the Observatory, the modes of reducing the observations, and other particulars, which make up the Introduction. The results of the observations occupy the next 427 pages. The appendix contains, 1st, a chapter on Neptune; 2, on the Electro-chronographs; and 3, on Wind and Current Charts. On the

last subject, Lieut. Maury has brought forward much that has not hitherto been published, and views of interest to meteorological science and navigation, whether they are all sustained or not by further study. Some of the views on the Gulf Stream and the northern current we find stated as early as the year 1837 in an article in this Journal by Mr. W. C. Redfield, and in part alluded to in 1835, vol. xxv, p. 131. But great additions have been made to our actual knowledge of oceanic currents and the courses of winds, and greater results promise to reward the skill and energy with which the researches are now prosecuted. We trust that Lieut. Maury may continue to have, and more completely, the coöperation of the Navy Department in carrying out his system of investigations; and we would commend the subject also to the commercial cruisers, who with little effort, might contribute to the general fund, facts of great value to commerce as well as science. Lieut. Maury also presents conclusions with reference to the circulation of the air, from the recent discoveries of Faraday respecting the magnetic character of oxygen, and other deductions from the researches of Ehrenberg on the organic life of the transported dust of the atmosphere. This part of the Report contains extended citations from Ehrenberg's recent work; and in view of the occurrence of South American forms of microscopic organisms in the Atlantic dust off the African coast, he suggests that the dust is carried off by "the whirlwinds which accompany the vernal equinox and sweep over the lifeless plains of the lower Orinoco," while those of "the autumnal equinox, take up the organisms of the upper Orinoco and great Amazon basins." The establishment of such a view will require farther investigation into the organisms of these different regions.

2. *Practical Mineralogy, Assaying and Mining*, with a description of the useful minerals, and instructions for assaying and mining according to the simplest methods; by FREDERICK OVERMAN, Mining Engineer. 230 pp. 16mo. Philadelphia, 1851. Lindsay and Blakiston.—There is much practical information in this little work, but it is not all to be relied on. We learn on the 2nd page that granite is the *oldest* of rocks; that it is *composed of fragments* of other rock or stony matter; it is of great hardness and strength and of *everlasting durability*;—on the 4th page, metamorphic rock, "also called transition rock is the second in age;" "to this class belong a great variety of *minerals* as gneiss, mica slate," &c. "Metamorphic rock often assumes the appearance of granite, *pudding-stone* or stratified rock;" and on page 7 the Connecticut sandstone is ranked with the metamorphic rocks: on page 8 we read under the head of Volcanic Rocks,—"the rocks belonging to this class are often found to be perfectly vitrified and of a glassy appearance *as basalt* and some kinds of lava; the first is found in columns grouped together in isolated mountains or *imbedded in other volcanic rocks*." We might go on in this citation of errors, but this will suffice.—Such a work is calculated to make error, rather than science, popular.

3. *A Chart giving an Ideal Section of the Successive Geological Formations*, with an actual Geological section from the Atlantic to the Pacific ocean, the whole illustrated by the characteristic fossils of each formation; by JAMES HALL.—This geological chart by Mr. Hall is intended for class instruction, and is well adapted for this purpose. It

measures five feet by six, and is conveniently mounted on rollers. The lower two-thirds of the sheet are occupied with an ideal geological section and the upper portion by drawings of fossils. The section is an excellent representation, as far as can be done in a single view, of the general principles of geology. Besides exhibiting the dynamics of the science and the succession of the rocks in due order, with their names in French and German as well as English, the author has given also the more important geographical positions in which the rocks occur. The New York strata as developed by the recent surveys, and the results of the explorations of other parts of our country, are throughout laid down, and a section of the whole country through to the Pacific is added, so that the chart is thus especially adapted for the American student. The drawings of fossils are arranged in groups, those of the same geological system together, and in all amount to two hundred and seventy-five. Mr. Hall's labors in Palæontology, so well known and so honorable to the state which he has served, have prepared him to present this subject with accuracy and completeness; and in no other publication of the kind will the student find presented to the eye so perfect an exhibition of the characteristic organic remains of the several strata. Such a chart has been greatly needed for the geological lecture room, and we know of none comparable with it for extent of information, or fullness, accuracy and neatness of illustration.

4. *The Christian Retrospect and Register*, a summary of the Scientific, Moral and Religious Progress of the first Half of the XIXth century; by ROBERT BAIRD, 420 pp., 12mo. New York, 1851.—This work embraces two distinct parts; the first, the progress of the world in general liberty, education, and the sciences; the second, its moral and religious advancement. Dr. Baird, through his intercourse with various nations of Europe and familiar knowledge of their religious history and condition, has been enabled to condense in this work a large amount of valuable information. The learned and excellent author treats separately of the progress of political liberty and education, the enlargement of the bounds of Christendom, the progress of religious liberty and the operations and prospects of the many societies now active for the diffusion of Scriptural knowledge. The portion of the volume devoted to science is by the Rev. B. N. Martin. A complete review was of course impossible in so small a compass. The author, without attempting to give a philosophical exhibition of the development of scientific knowledge, has briefly glanced at many of the steps of progress under the head of the different departments of science and certain of the arts.

5. *Annals of the Lyceum of Natural History of New York.* Vol. V, No. 2, April, 1851.

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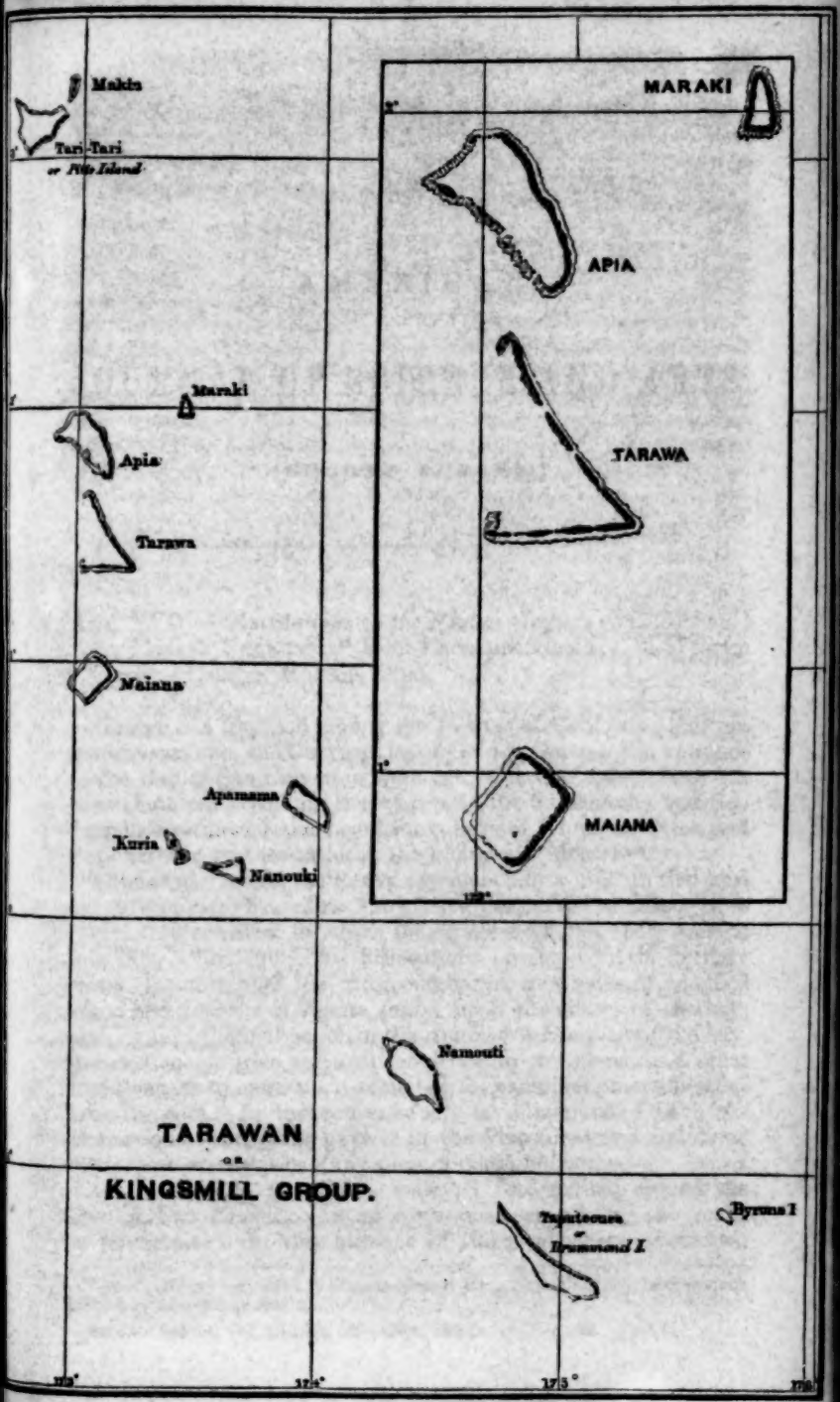
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